# Evaluating an Urban Stream Restoration for Improving Bank Stability, In-Stream Habitat, and Water Quality


**Scott Struck, Ari Selvakumar, and Tom O'Connor**
U.S. EPA ORD-NRMRL

**Paula Estornell, Ann Carkhuff, and Charles App**
U.S. EPA Region III

**Adrian Fremont**
City of Fairfax, Virginia

**Ken Hyer**
U.S. Geological Survey

# *Outline*

- Purpose
- Partners
- Site Selection
- Selected Site Conditions
- Monitoring Results
- Conclusions

# Purpose

| | |
|---|---|
| **Long Term Goal** | Provide evaluation of tools to restore and protect aquatic systems and forecast the ecological, economic, and human health outcomes of alternative watershed management solutions |
| **Short Term Goal** | Short Term Goal: Monitoring and development of predictive relationships to evaluate receiving water improvements following urban stream restoration |

**Phase I** • Stream bank and channel restoration

**Phase II** • Other targeted watershed enhancements

# Scientific Objective

**Phase I (Shorter Term)**

Develop from monitoring data predictive relationships to evaluate the effectiveness of stream bank and channel restoration for:

- Reducing bank cutting and sedimentation
- Protecting critical infrastructure and property
- Increasing available biological habitat

**Phase II (Longer Term)**

Monitor watershed enhancements to develop predictive relationships that assess the effectiveness of targeted watershed Improvements:

- Identify locations based on multiple benefits
- Management based on stressors of concern
- Demonstrate green technologies
- Improve water quality and eliminate stream impairment

# Regulatory Objective

## Phase I (Shorter Term)

- Reduce sediment inputs to the stream
- Protect critical infrastructure and property
- Improve macroinvertebrate indices scores

## Phase II (Longer Term)

- Identify watershed improvement locations based on multiple benefits
- Manage watershed based on stressors of concern
- Demonstrate green technologies – including both structural and nonstructural practices
- Improve water quality and eliminate stream impairment
- Provide tools to MS4 communities that effectively reduce or eliminate stream impairment (achieve TMDL)

# *Project Desiress*

## Locational Needs:

- A planned, designed, and funded stream restoration with a start date of Spring 2006
- Protection of a low-order stream
- Monitoring data of baseline conditions of the pre-installation health of the stream ecology
- Pre-installation data on stressors that impact stream ecology
- Within driving distance of Edison, NJ
- Location with safe, all-season access and some assurances of equipment security

# *Other Desirable Site Criteria*

- The installation preferably has established performance expectations
- The receiving waterbody is within an MS4
- The receiving waterbody is 303(d) listed (may have TMDL in place or in development)
- A stream with USGS gauging station
- A watershed with a stream that is either moderately degraded or slightly degraded
- Planned post-BMP monitoring to evaluate the improvement and health of the stream

# *Possible Locations*

**Location candidates:**

- TBD by NJDEP
- Lower Beaverdam Creek, MD
- Donaldson Run in Arlington County, VA
- Balston Beaver Pond, Arlington, VA
- Four Mile Run, VA
- **Accotink Creek, Fairfax, VA**

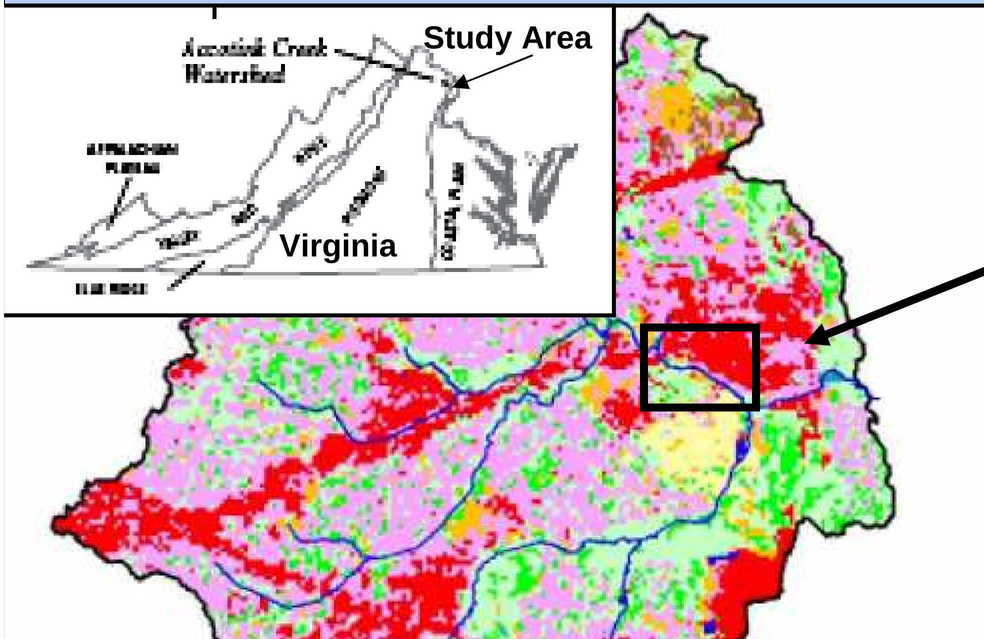
# *City of Fairfax Restoration Goals*

- Restore the stream channel to a stable, self-maintaining condition and reduce stream bank erosion
- Improve low flow habitat conditions
- Improve index scores for macroinvertebrates
- Improve fish habitat and density
- Meet State WQS for fecal coliform/E.coli (2004) and aquatic life impairment (1998)

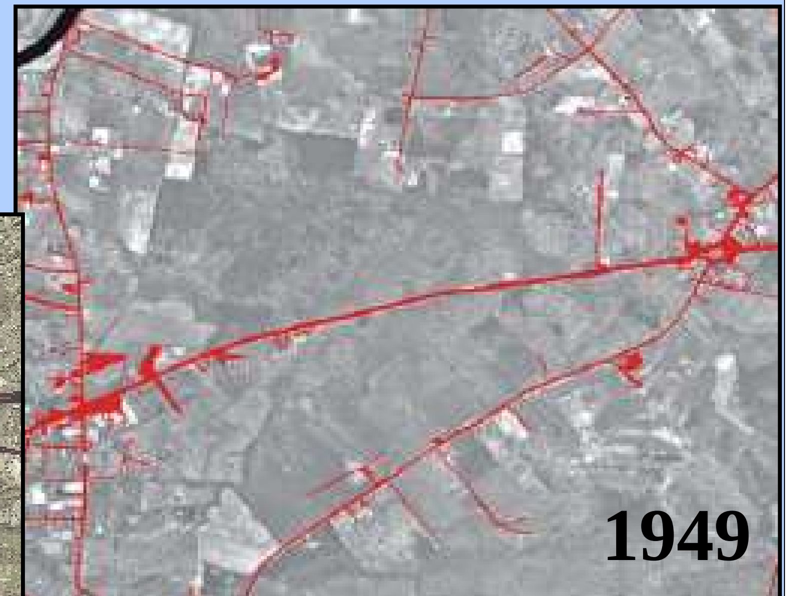
# *Project Partners*

- U.S. EPA ORD - NRMRL
- U.S. EPA Region III
- City of Fairfax, Virginia
- Center for Watershed Protection (CWP)-Cooperative Agreement with EPA Region III
- United States Geological Survey (USGS)
- Virginia Department of Environmental Quality (VADEQ)
- Northern Virginia Regional Council
- Virginia Department of Conservation and Recreation (VADCR)

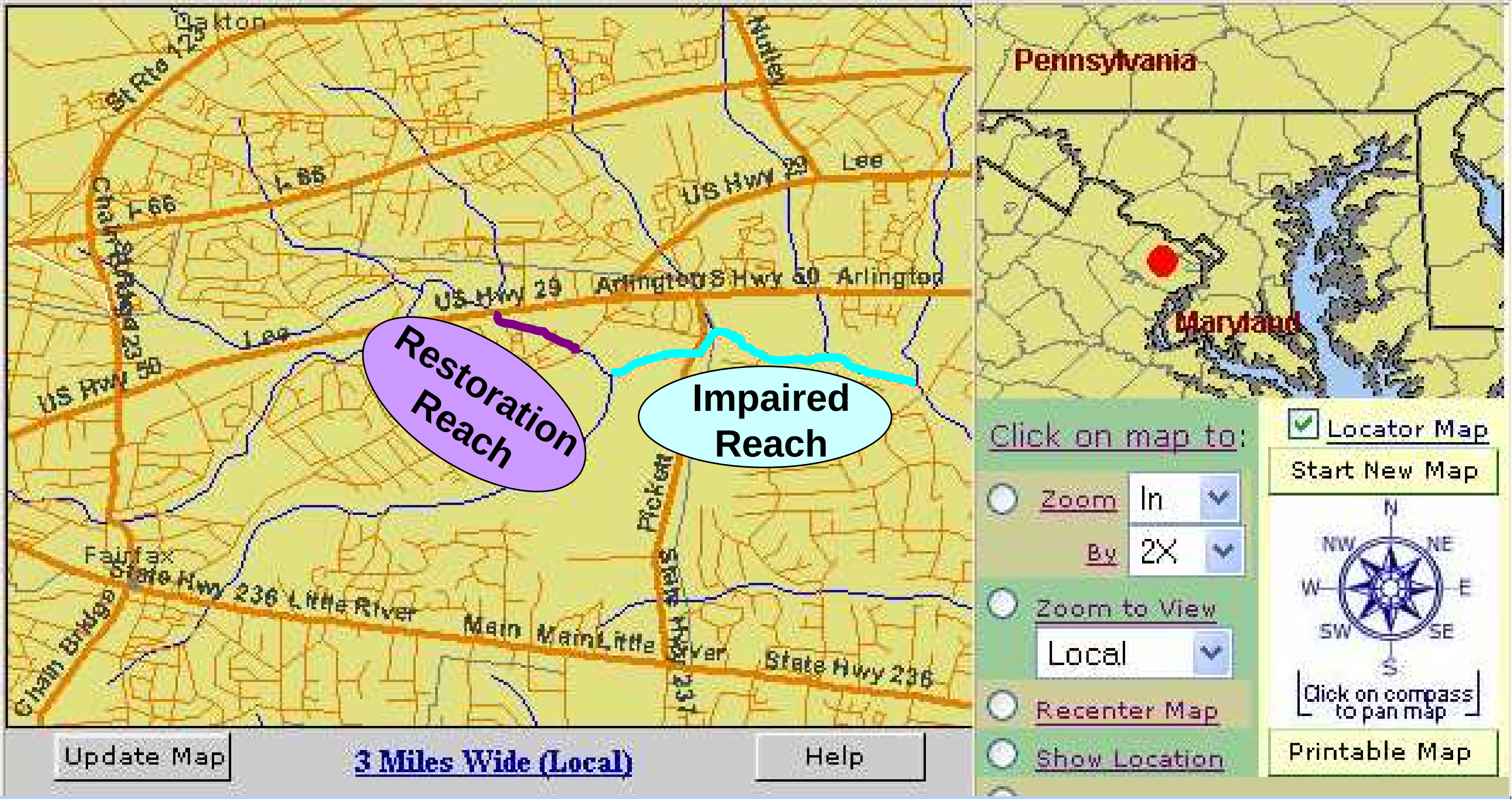
# Accotink Watershed Land Use




**Area of Interest for Restoration**




# 303d Listed Impaired Waters



# Water Quality Attainments

| Designated Use Category | State Designated Use | Attainment Status | Threatened |
|---|---|---|---|
| Fish, Shellfish, and Wildlife Protection and Propagation | AQUATIC LIFE SUPPORT | NOT SUPPORTING | No |
| Recreation | PRIMARY CONTACT (RECR) | NOT SUPPORTING | No |

**2006 303(d) List Summary of Impaired Waters (Category 5) Needing TMDL Study***

**Potomac and Shenandoah River Basins**

| TMDL Watershed Name<br>TMDL Group ID | Use | Impairment | River (Miles) | Reservoir (Acres) | Estuary (Sq. Miles) | Initial List Date | TMDL Dev. Date |
|---|---|---|---|---|---|---|---|
| **Accotink Creek** | | | | | | | |
| 00313 | Aquatic Life | Total Size Benthic-Macroinvertebrate Bioassessments (Streams): | 8.62 | | | 1998 | 2008 |
| 60150 | Recreation | Total Size Escherichia coli: | 1.19 | | | 2004 | 2014 |
| 01784 | Recreation | Total Size Fecal Coliform: | 8.62 | | | 2004 | 2016 |

# Probable Sources Contributing to Impairment

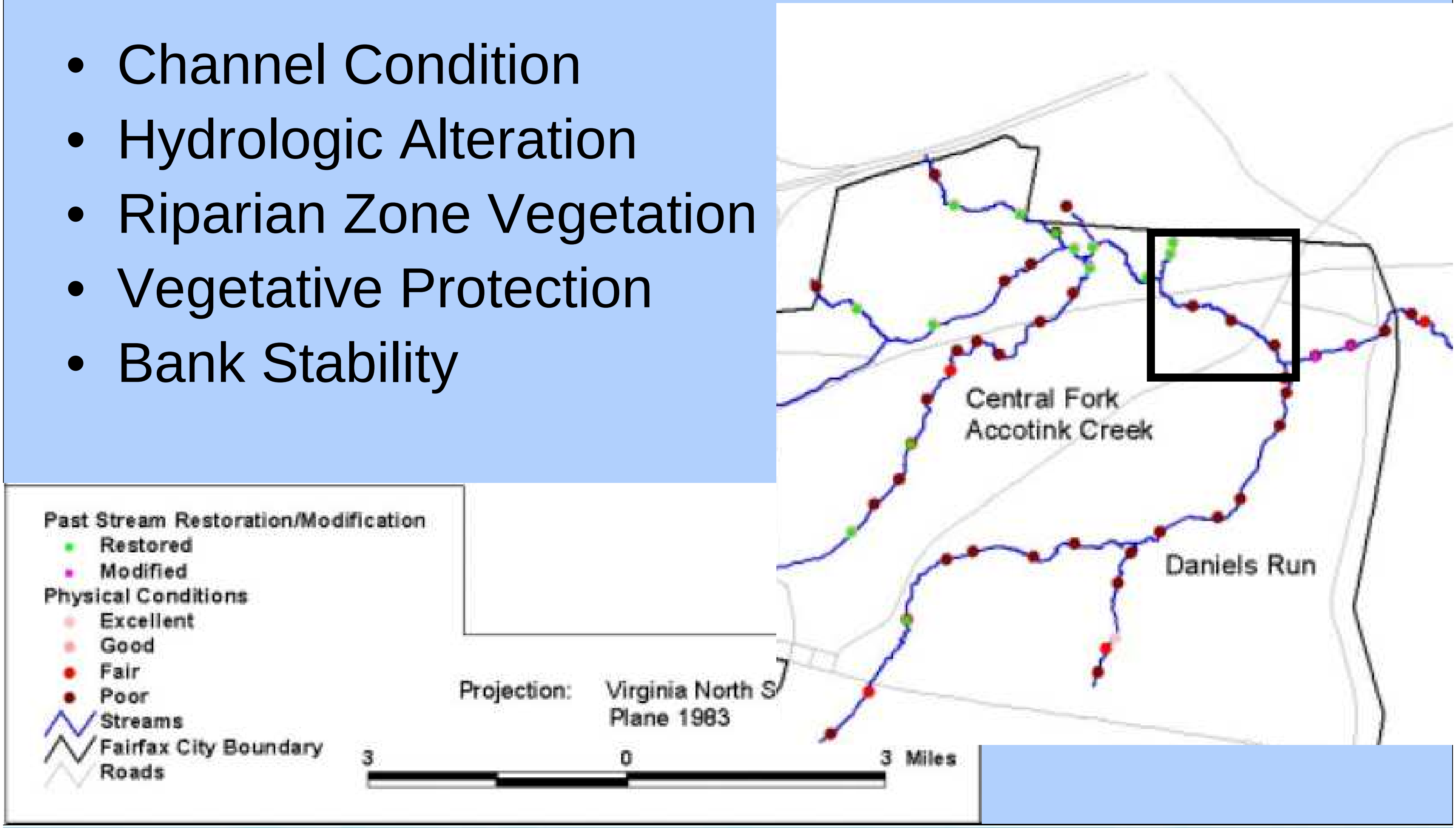
| State Source | EPA Source Classification |
|---|---|
| WATERFOWL | NATURAL |
| MUNICIPAL (URBANIZED HIGH DENSITY AREA) | URBAN-RELATED RUNOFF/STORMWATER |
| ILLICIT CONNECTIONS/HOOK-UPS TO STORM SEWERS | SPILLS AND UNPERMITTED DISCHARGES |

# *Pre-Restoration Conditions of the Watershed*

- Physical Conditions
- Habitat and Biological Conditions
- Velocity vs. Stream Condition

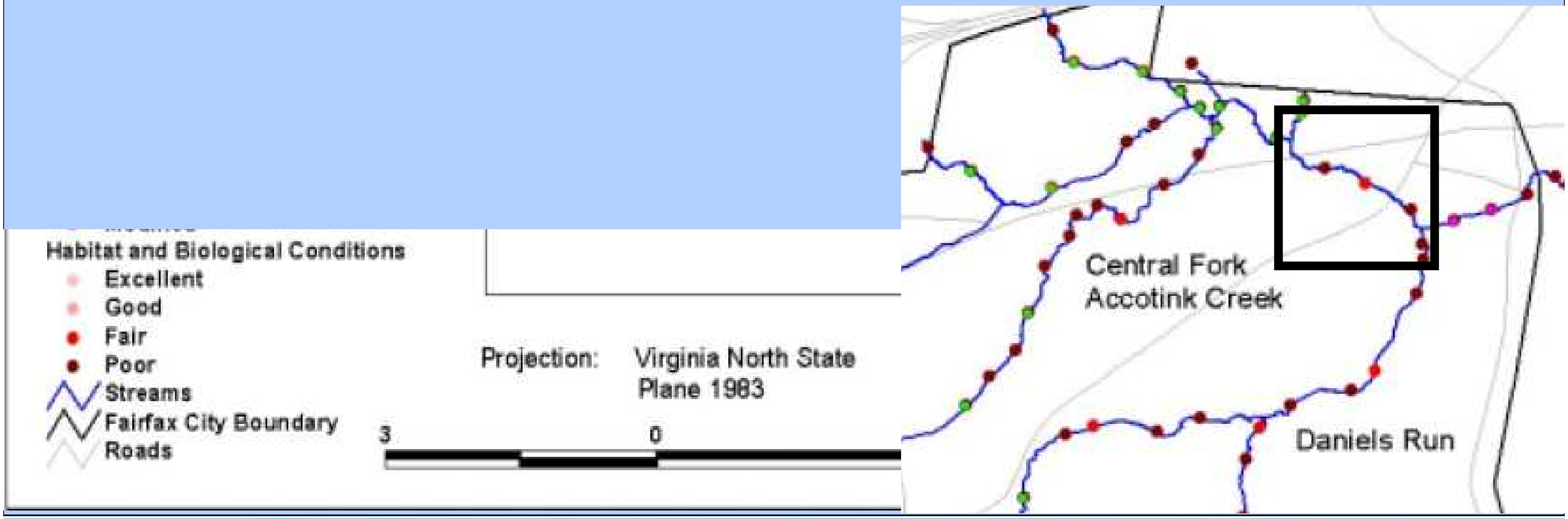
# Physical Conditions

- Channel Condition
- Hydrologic Alteration
- Riparian Zone Vegetation
- Vegetative Protection
- Bank Stability

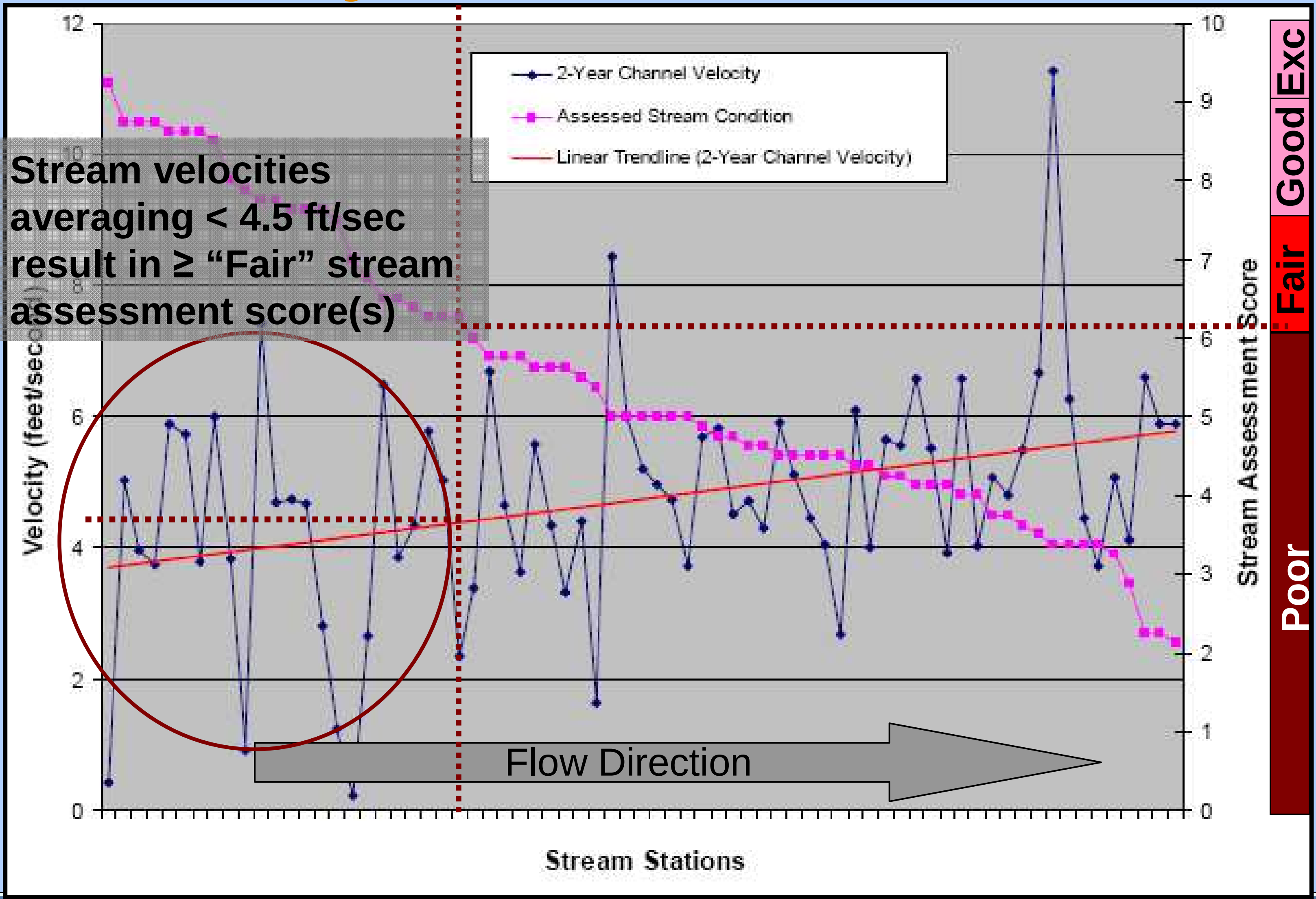


# *Habitat and Biological Characteristics of the Streams*

- Sediment Deposition
- Water Appearance
- Nutrient Enrichment
- Barriers to Fish Movement
- In-Stream Fish Cover
- Pools
- Insect/Invertebrate Habitat
- Canopy Cover
- Riffle Embeddedness
- Macroinvertebrates Observed



# Relationship Between Channel Velocity and Stream Condition

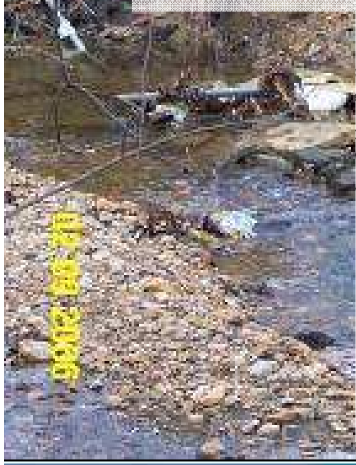


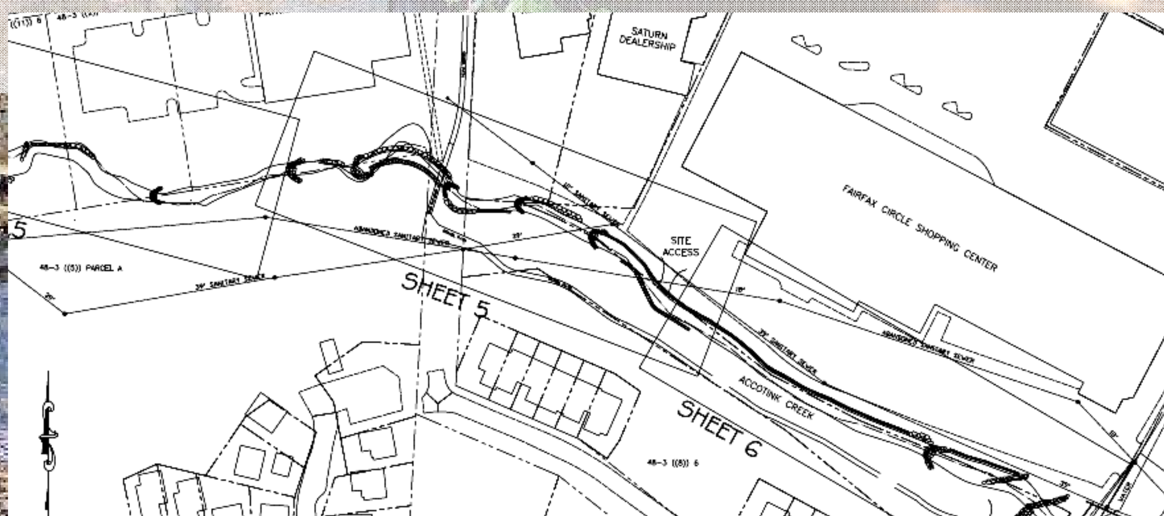
# Restoration of Accotink Creek, VA

## Restore 1800 Linear Feet of Stream Channel

**Tools:**

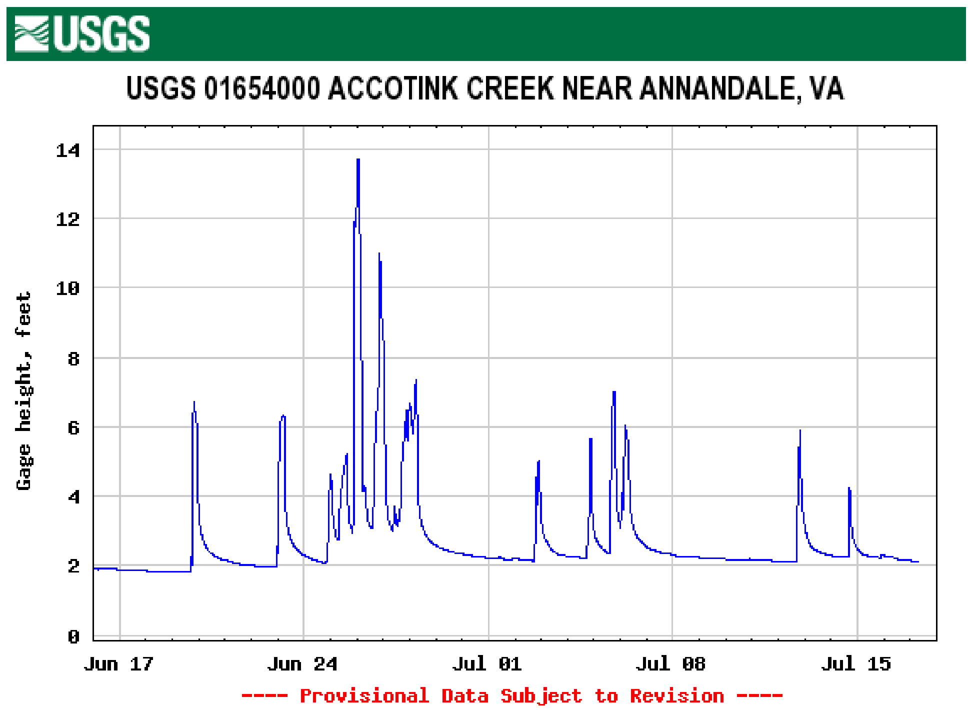
- **Imbricated rock wall**
- **Rock veins for slope reduction and pool formation**
- **Reduce slope of bank**
- **Widen stream channel (where possible)**

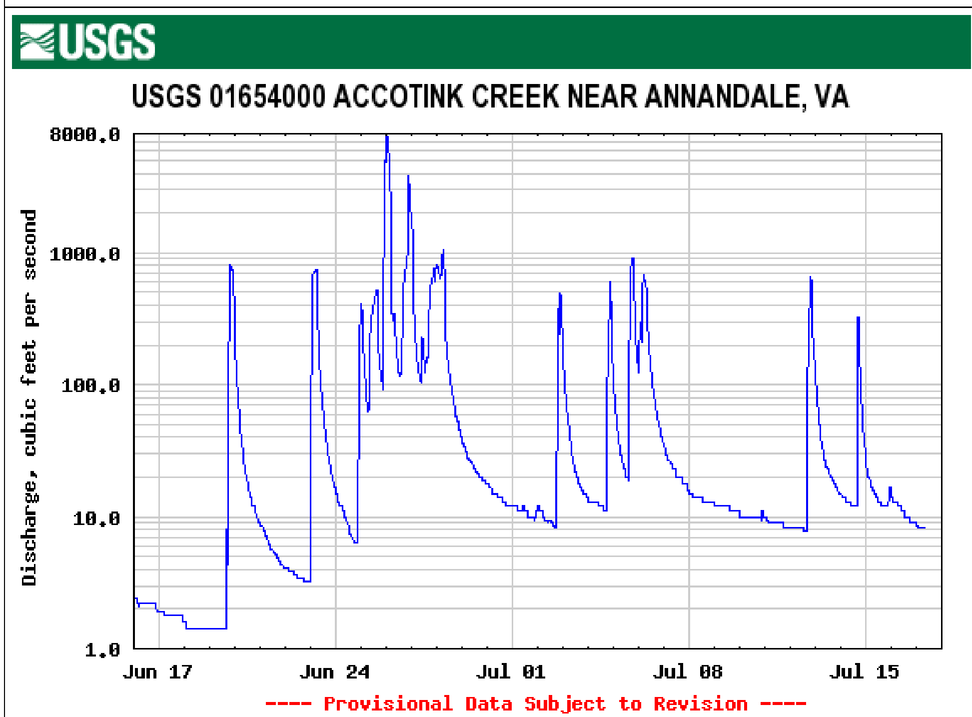




# *Restoration Completed*

- Restoration Completed June 6th, 2006
- 3” rainfall in 2 hours on June 9th
- Post-Storm Walk through June 21st
- MAJOR Flooding June 23rd – 26th (closed U.S. EPA Headquarters in D.C. for 5 days)




**June 28, 2006**

"In Fairfax County, Va., two streamflow gages recorded peaks near the 50-year recurrence interval and one streamflow gage recorded a peak near the 100-year recurrence interval."

-USGS and NWS

EVELOPMENT

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Building a scientific f

# *Monitoring of Restoration*

- Continuous monitoring of WQ and flow using YSI-EDS's and AS velocity/depth probes
- WQ wet and dry weather discrete samples
- Quarterly biological sampling
  - Benthic macroinvertebrates
  - Vegetation cover
- Annual stream morphology sampling
  - Cross-sectional surveying
  - Longitudinal surveying
- Quarterly stream pebble counts

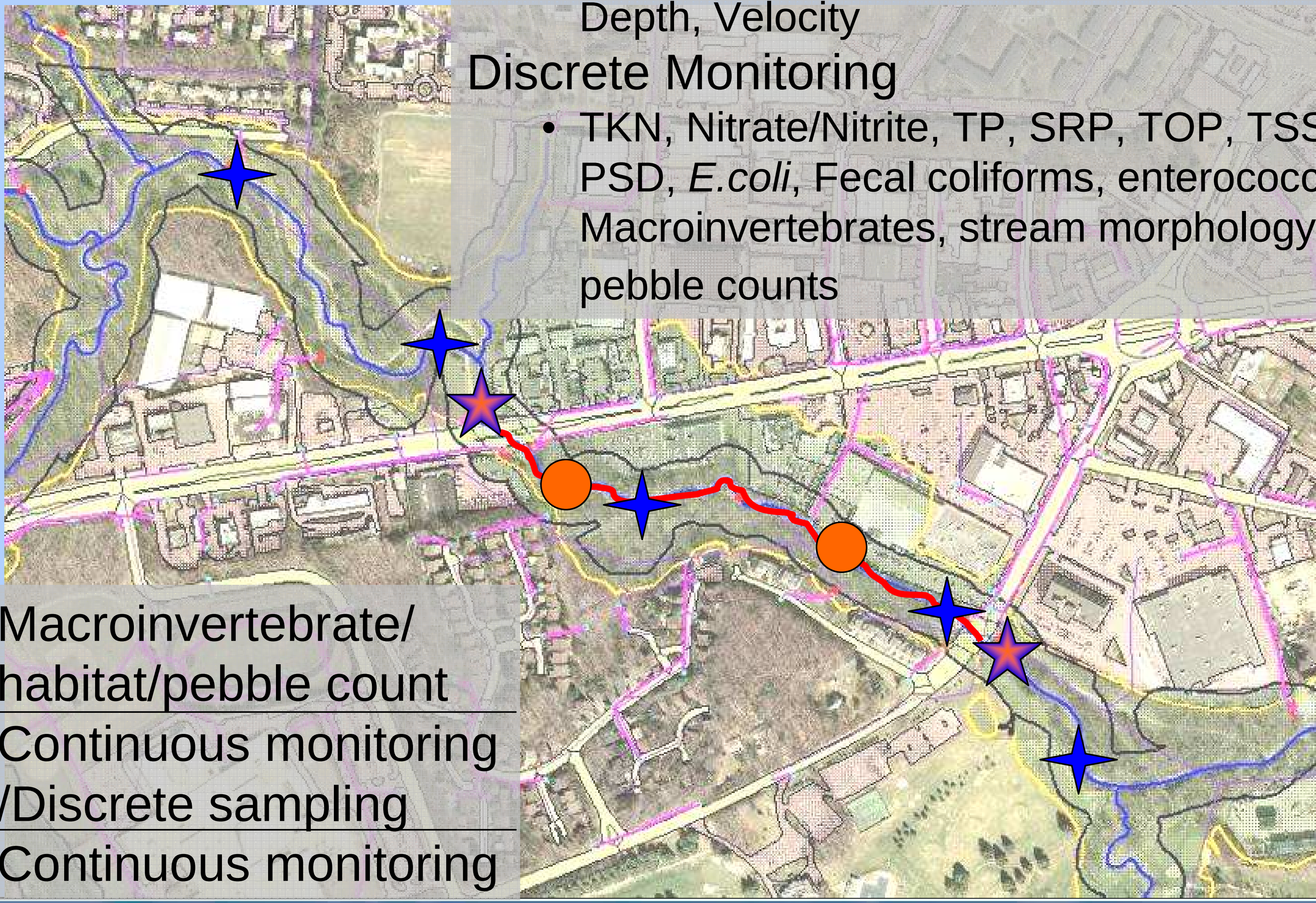
# Monitoring

Continuous Monitoring:

- pH, Turbidity, Temp, Conductivity, DO, Depth, Velocity

Discrete Monitoring

- TKN, Nitrate/Nitrite, TP, SRP, TOP, TSS, PSD, *E.coli*, Fecal coliforms, enterococci, Macroinvertebrates, stream morphology, pebble counts

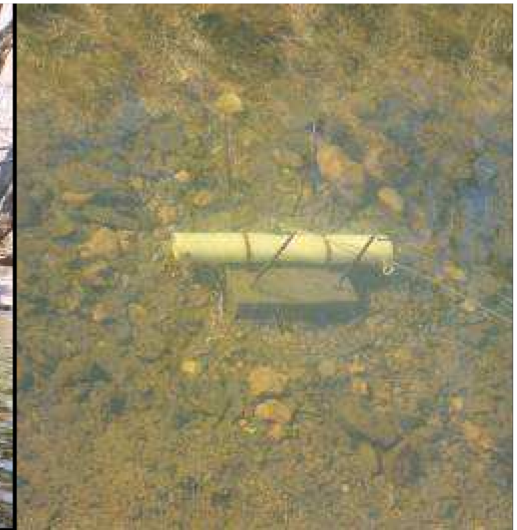


Macroinvertebrate/ habitat/pebble count

Continuous monitoring /Discrete sampling

Continuous monitoring

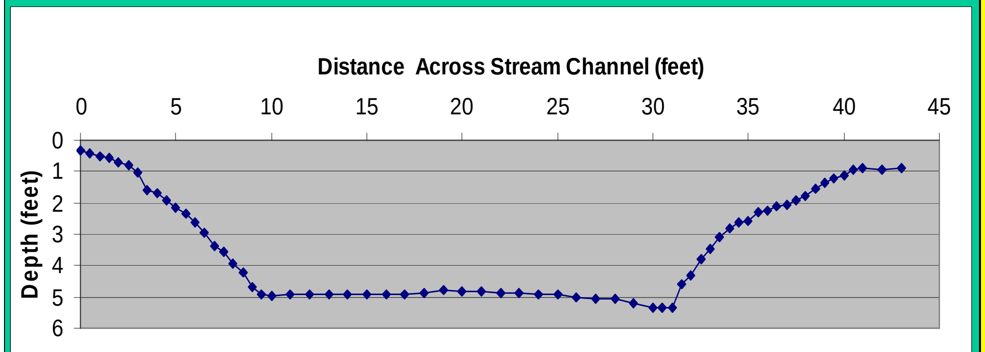
# *Sampling Results*



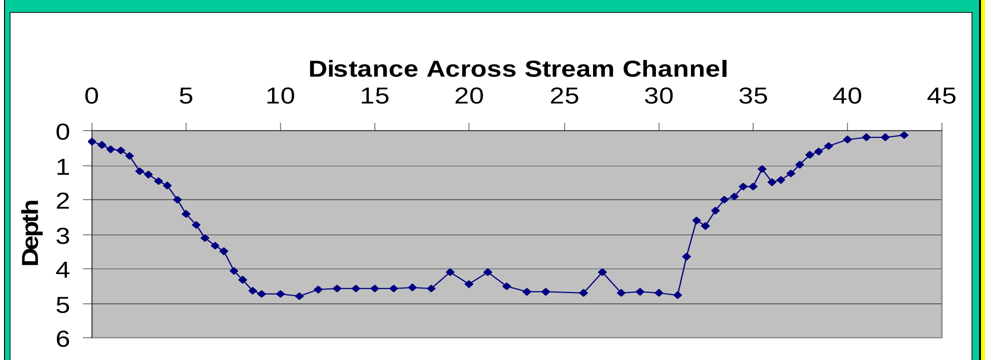
**Please note that all US EPA and USGS data are provisional**

# Cross-Sections

## Site A – Upstream of Restoration

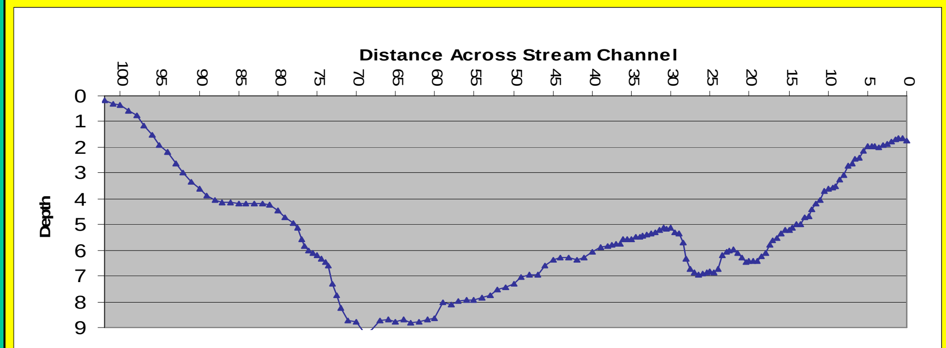



Before Restoration

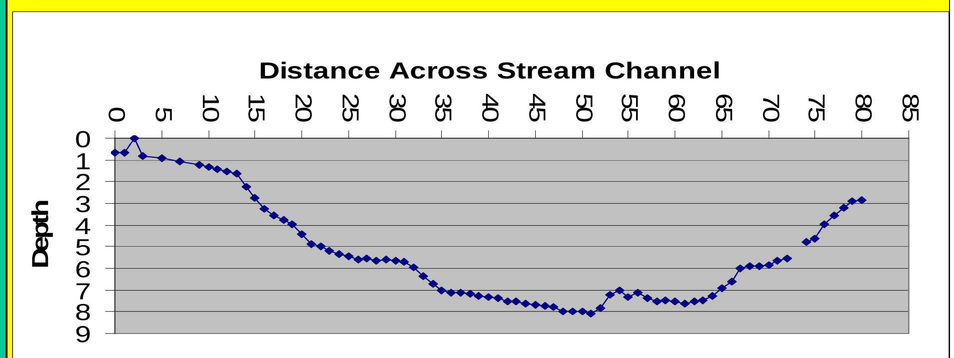



After Restoration

## Site C – Lower Part of Restoration

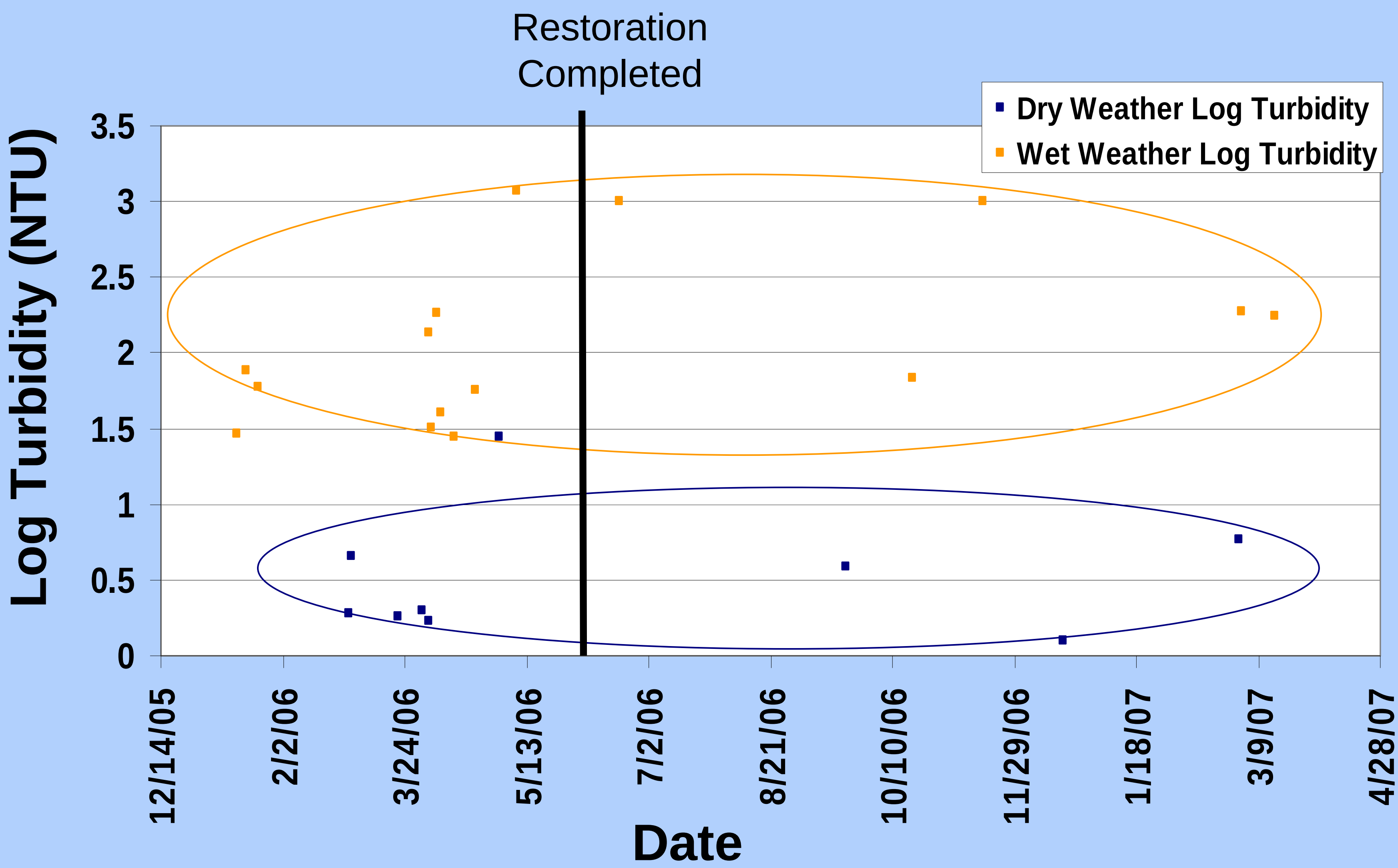



Before Restoration

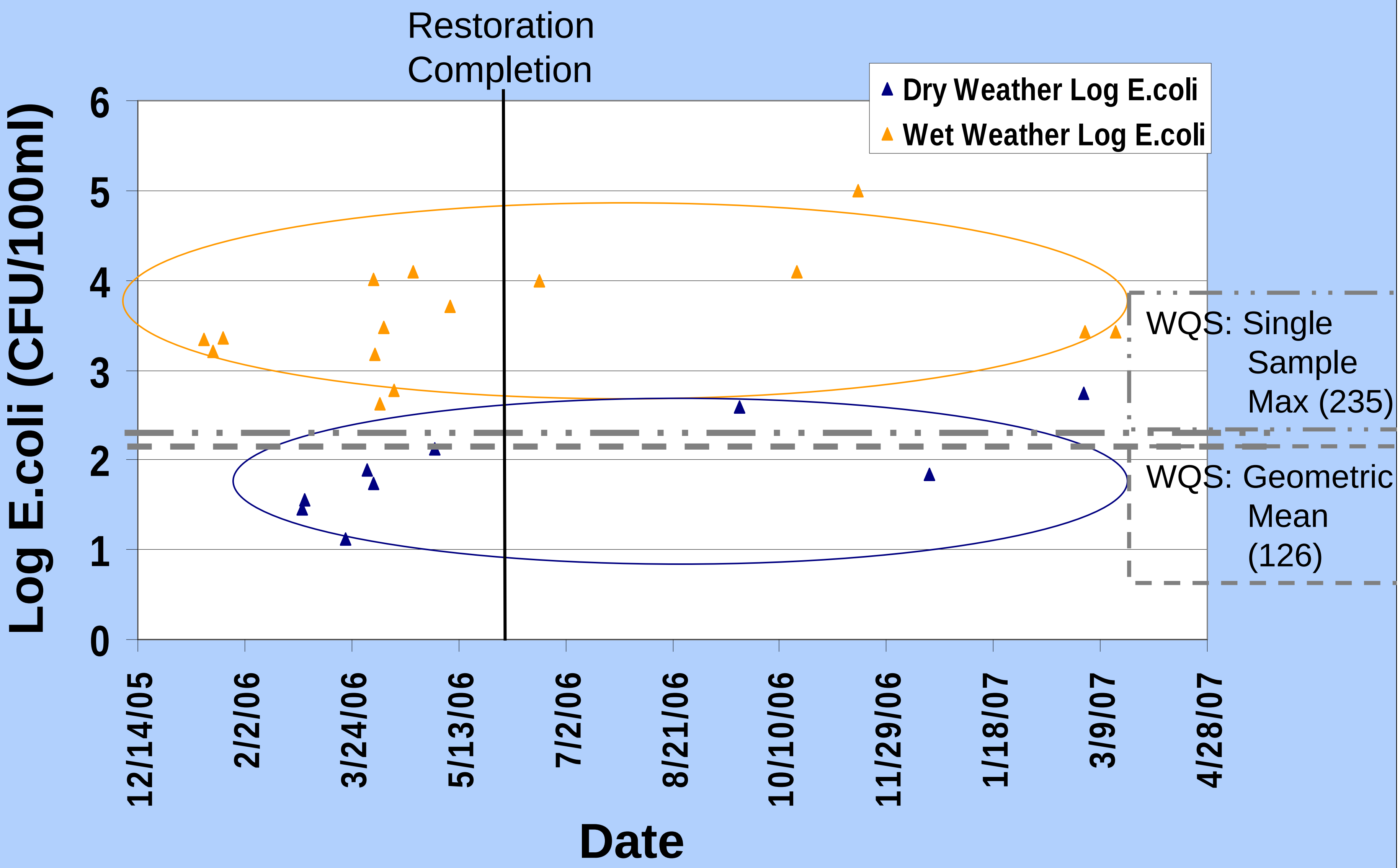


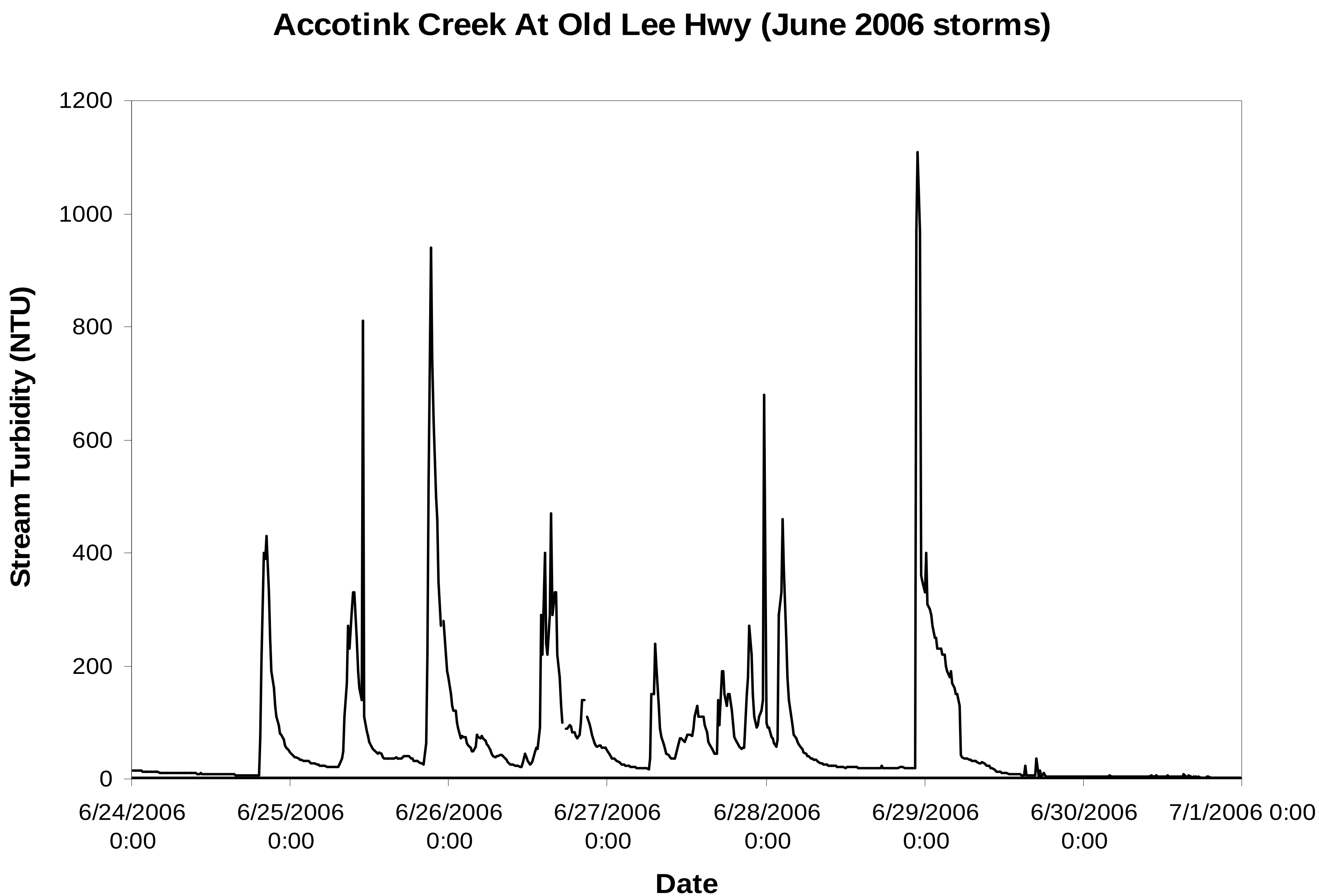

After Restoration

# Turbidity Data



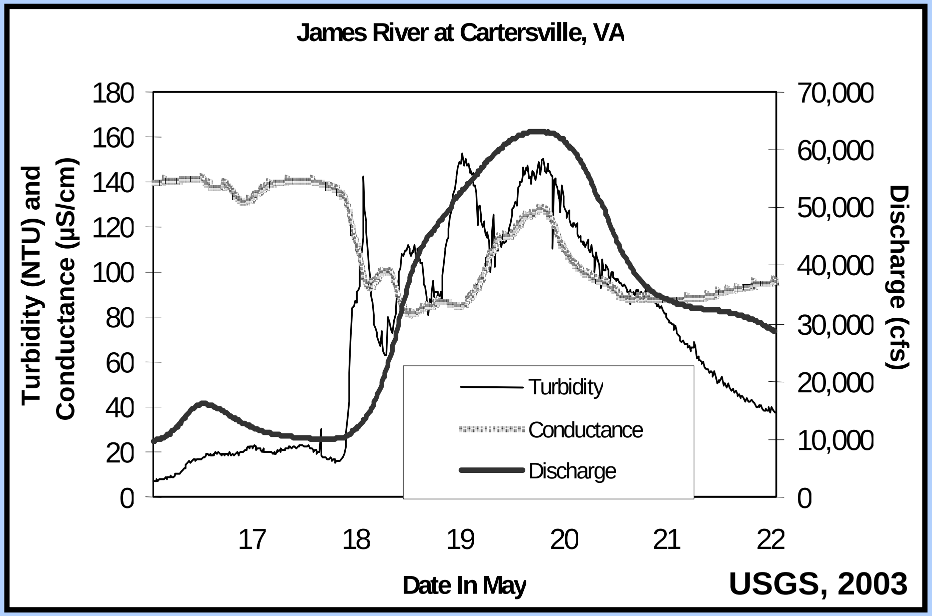
# E.coli Concentrations

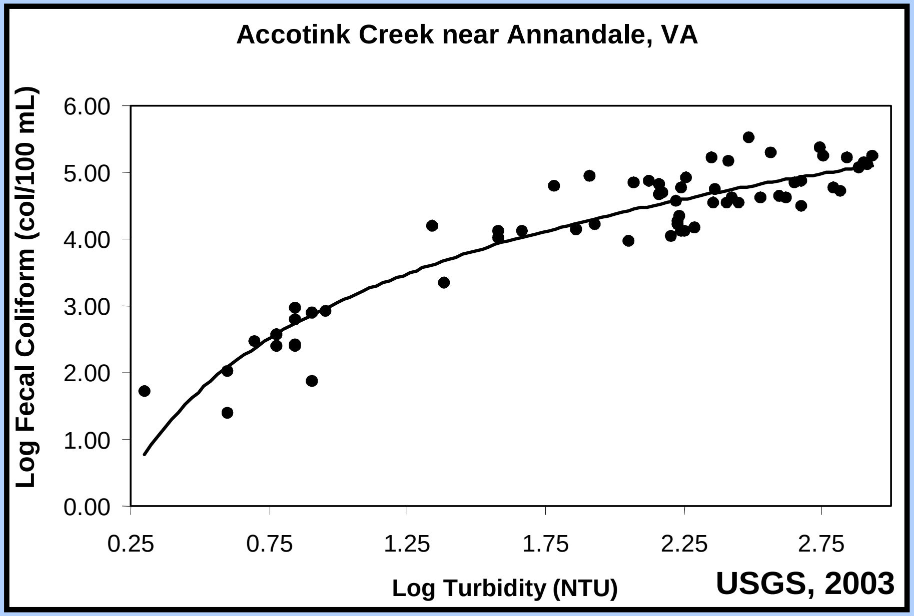



Accotink Creek At Old Lee Hwy (June 2006 storms)
Stream Turbidity (NTU)
1200
1000
800
600
400
200
0
6/24/2006 0:00
6/25/2006 0:00
6/26/2006 0:00
6/27/2006 0:00
6/28/2006 0:00
6/29/2006 0:00
6/30/2006 0:00
7/1/2006 0:00
Date

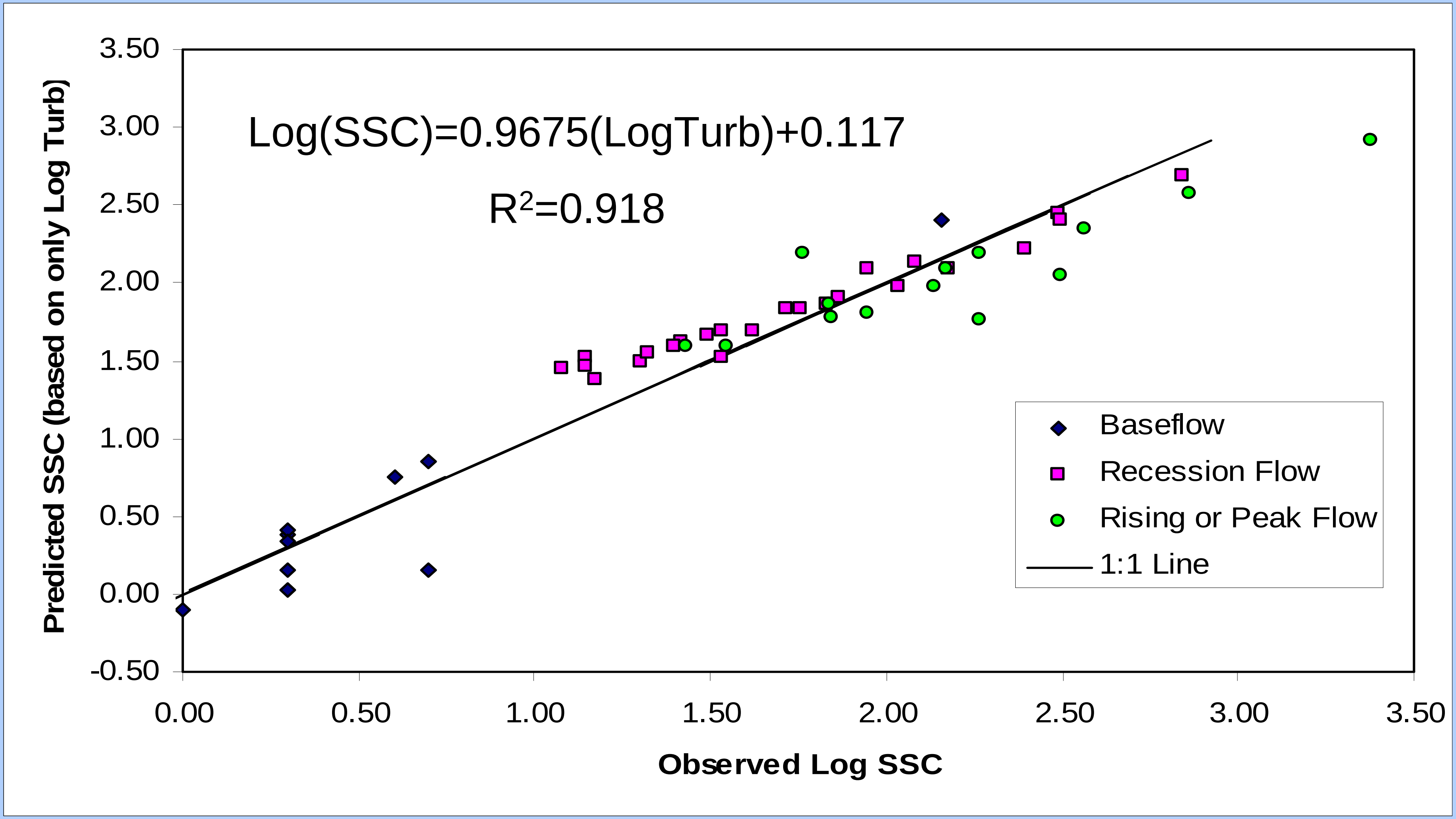
# Combining Discrete and Continuous Data

- Use continuous monitoring parameters (i.e. turbidity).
- Regress with discrete WQ parameters (i.e. fecal coliform, suspended sediment)
- Develop concentration estimation curves (similar to water level/flow rating curves)



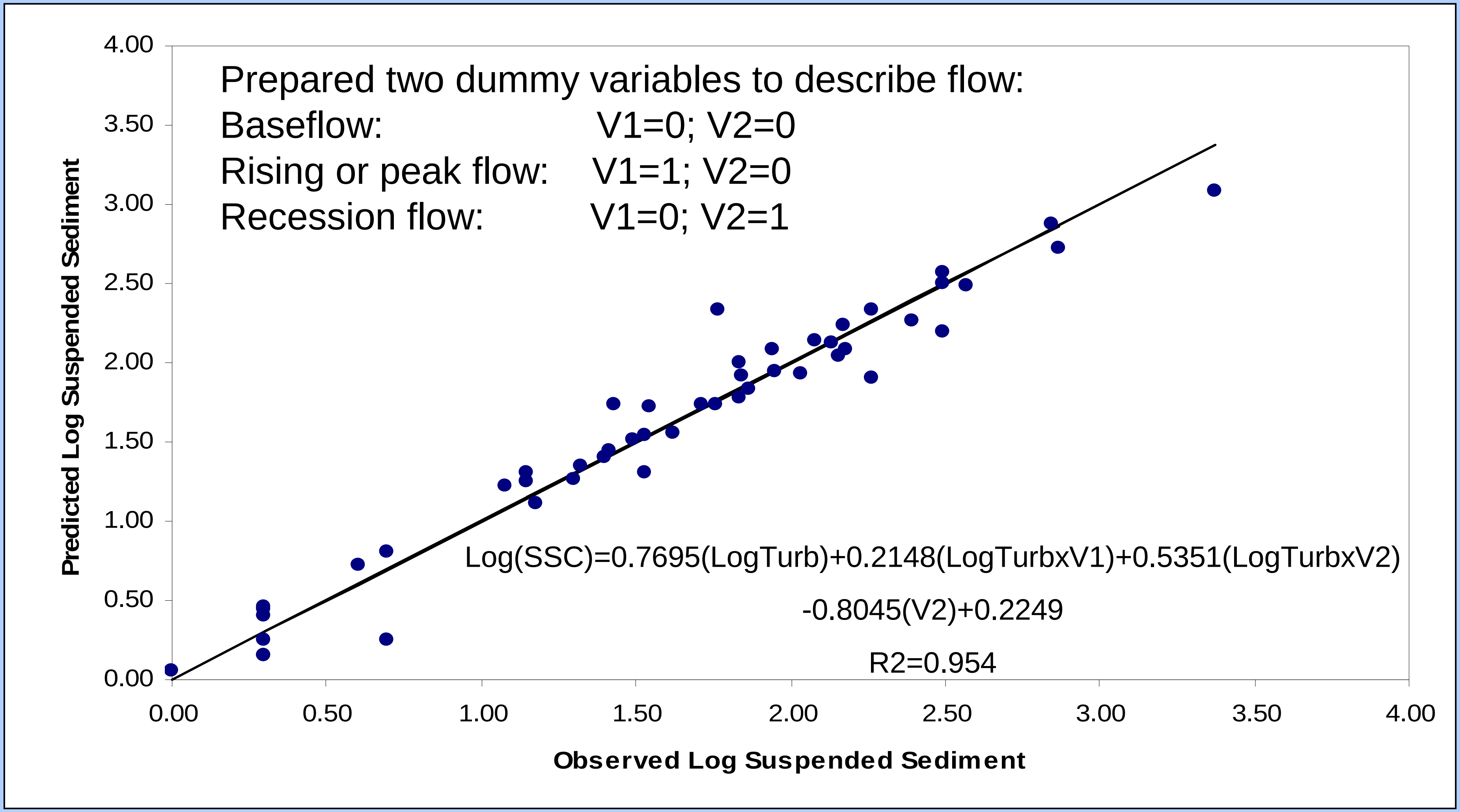



# Predicting Suspended Sediment Conc (SSC)



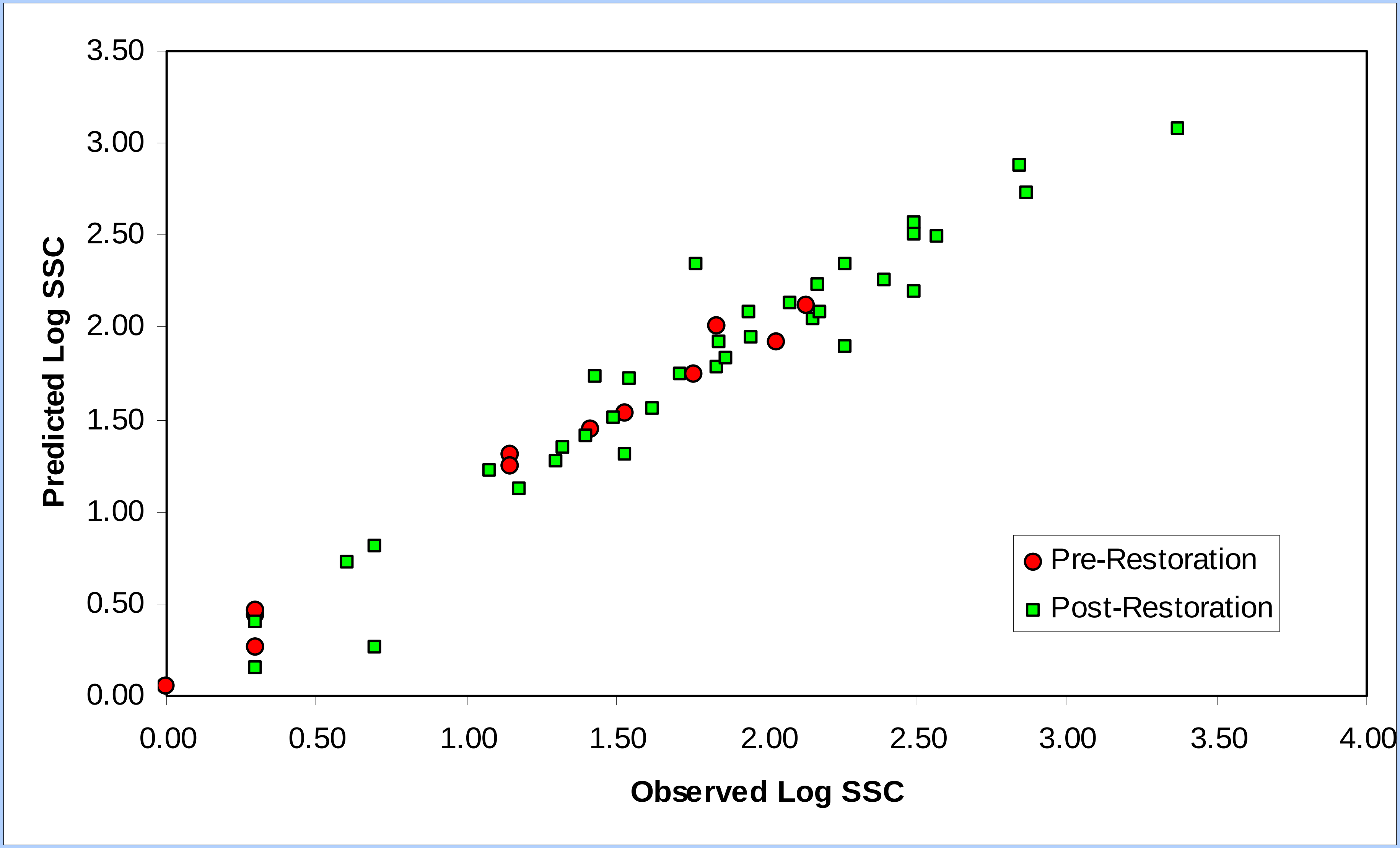

This simple model is reasonable, but there appears to be variability based on hydrological conditions (this is especially evident in the residuals)…

# Predicting Suspended Sediment Conc (SSC)



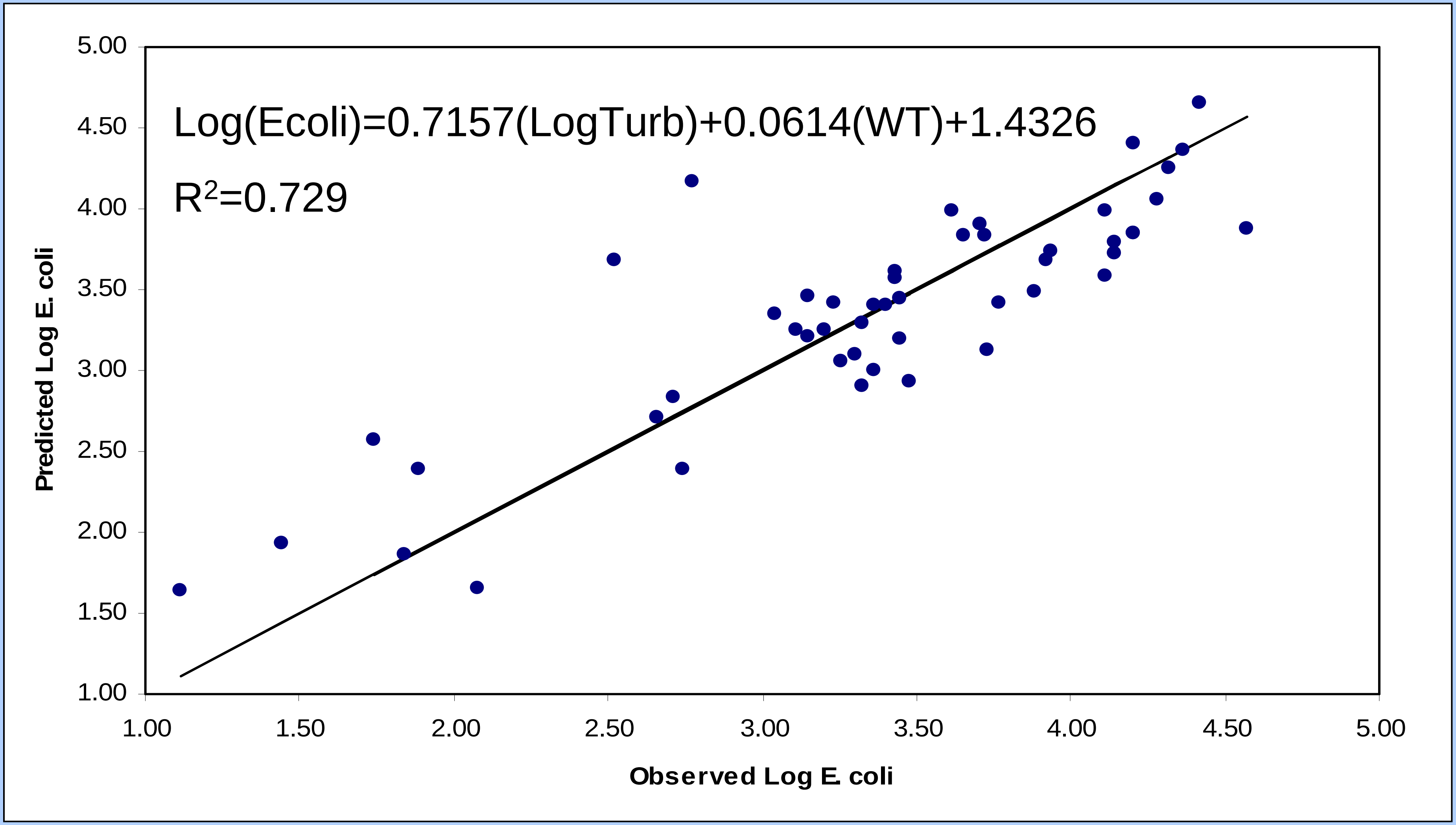

Revised model that includes flow conditions improves the prediction of SSC (and the residuals look much better)

# Effect of Sample Timing?



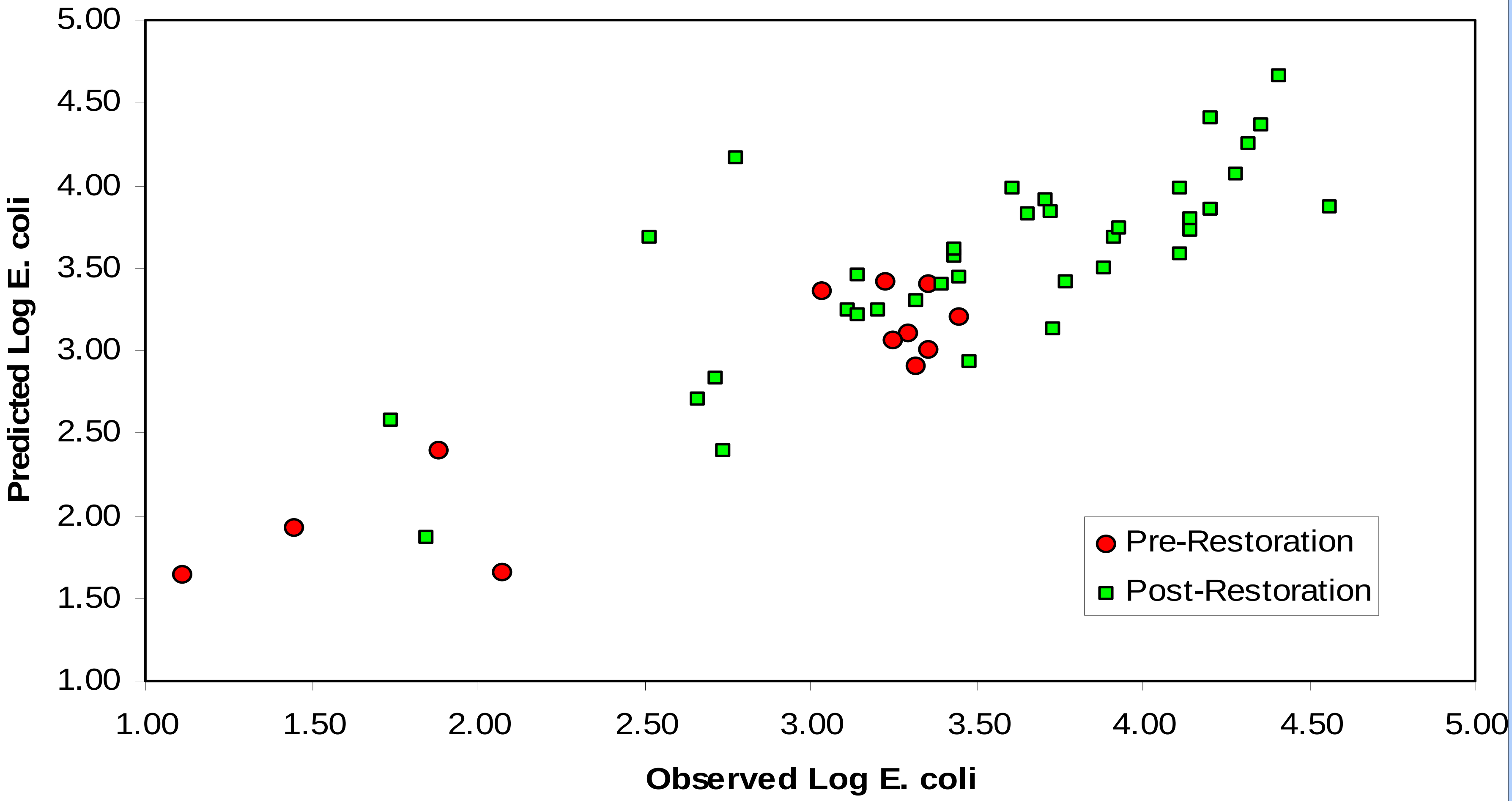

No statistically significant difference between Pre- and Post-Restoration data.

# Predicting E. coli Concentrations




A reasonable predictive model can be developed, but the data are much more variable than the sediment data.

# Effect of Sample Timing?




No statistically significant difference between Pre- and Post-Restoration data.

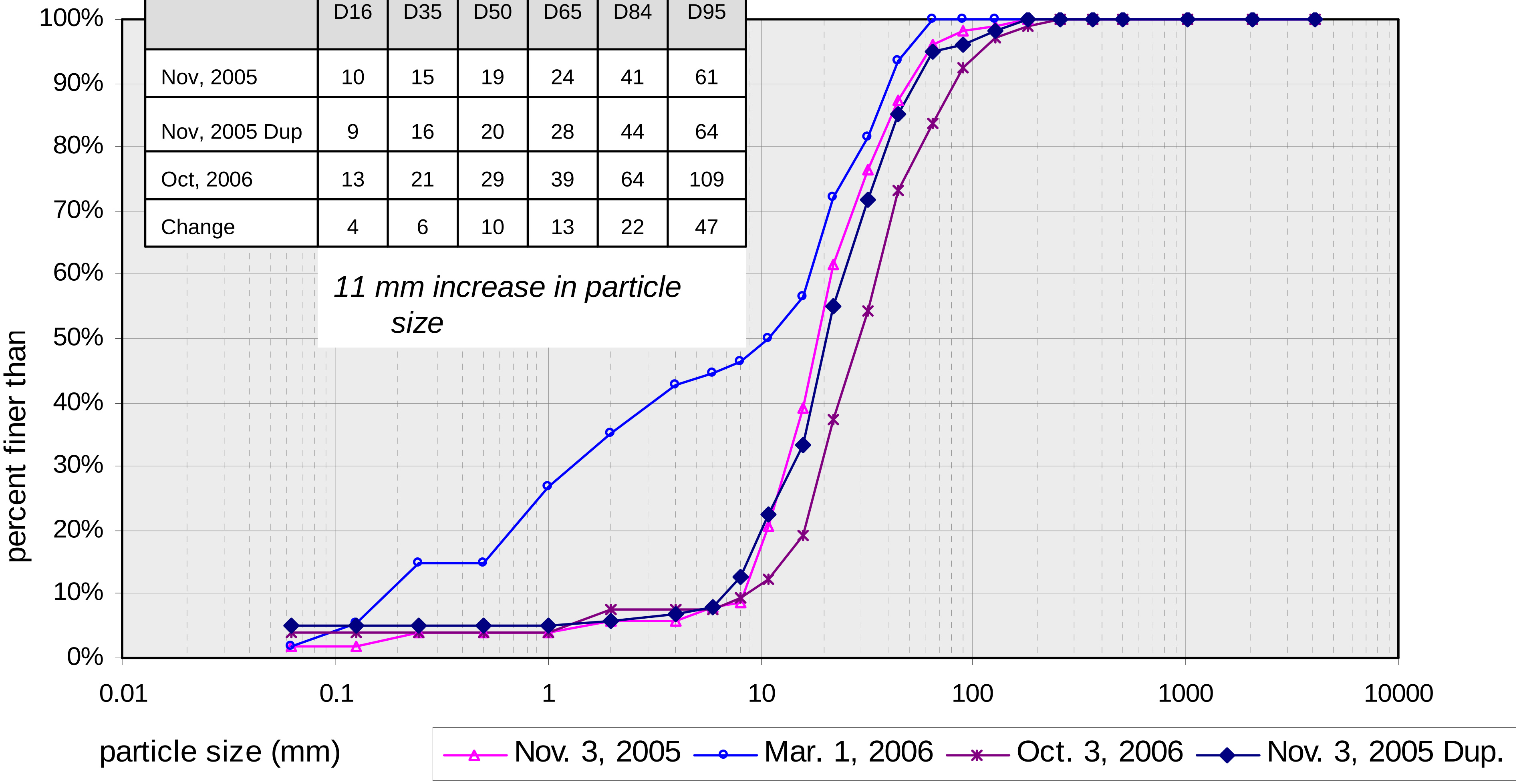
# Pebble Count Data – Changes in streambed substrate?

Site D - Downstream of Old Lee Highway

**Below Restoration**

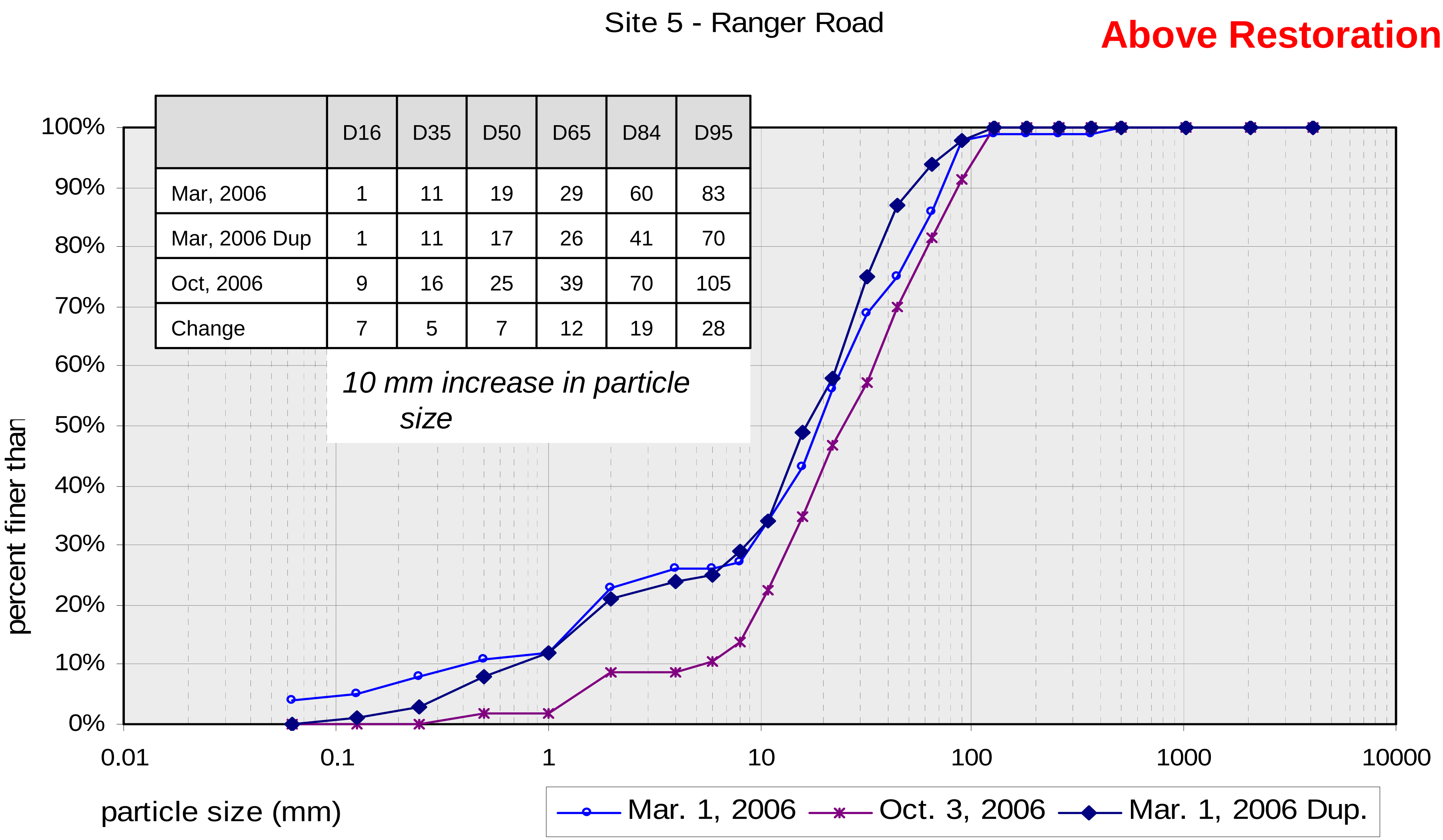
| | D16 | D35 | D50 | D65 | D84 | D95 |
|---|---|---|---|---|---|---|
| Nov, 2005 | 10 | 15 | 19 | 24 | 41 | 61 |
| Nov, 2005 Dup | 9 | 16 | 20 | 28 | 44 | 64 |
| Oct, 2006 | 13 | 21 | 29 | 39 | 64 | 109 |
| Change | 4 | 6 | 10 | 13 | 22 | 47 |

*11 mm increase in particle size*



# Pebble Count Data – Changes in streambed substrate?

**Above Restoration**

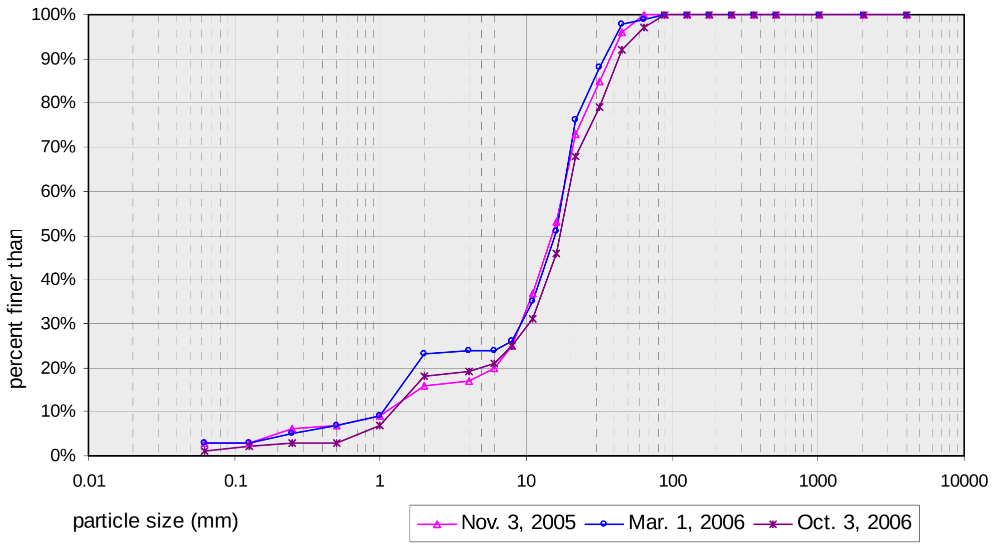



| | D16 | D35 | D50 | D65 | D84 | D95 |
|---|---|---|---|---|---|---|
| Mar, 2006 | 1 | 11 | 19 | 29 | 60 | 83 |
| Mar, 2006 Dup | 1 | 11 | 17 | 26 | 41 | 70 |
| Oct, 2006 | 9 | 16 | 25 | 39 | 70 | 105 |
| Change | 7 | 5 | 7 | 12 | 19 | 28 |

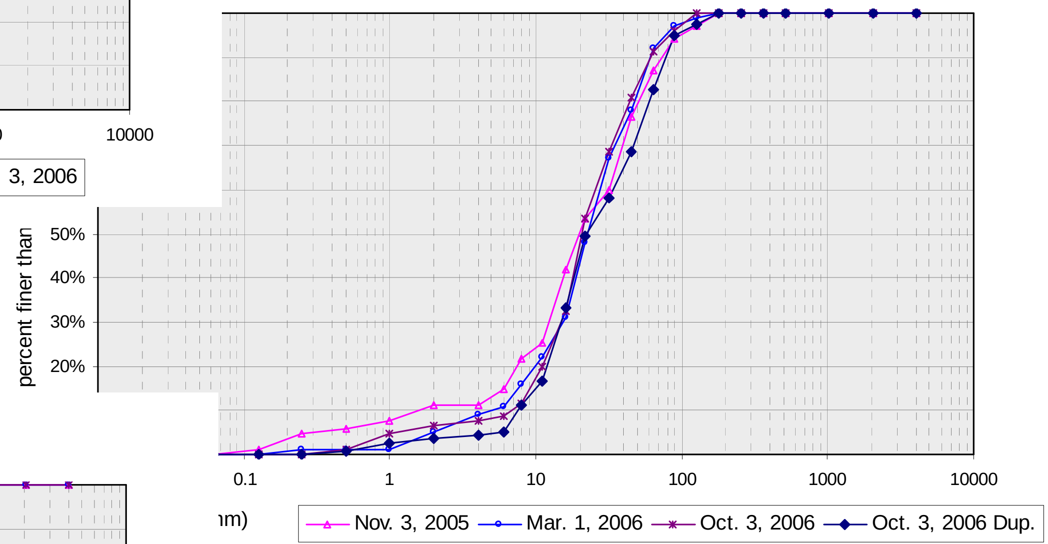
Particle size change may not result from restoration, based on upstream control.

# The remaining three sites demonstrate little variability over time

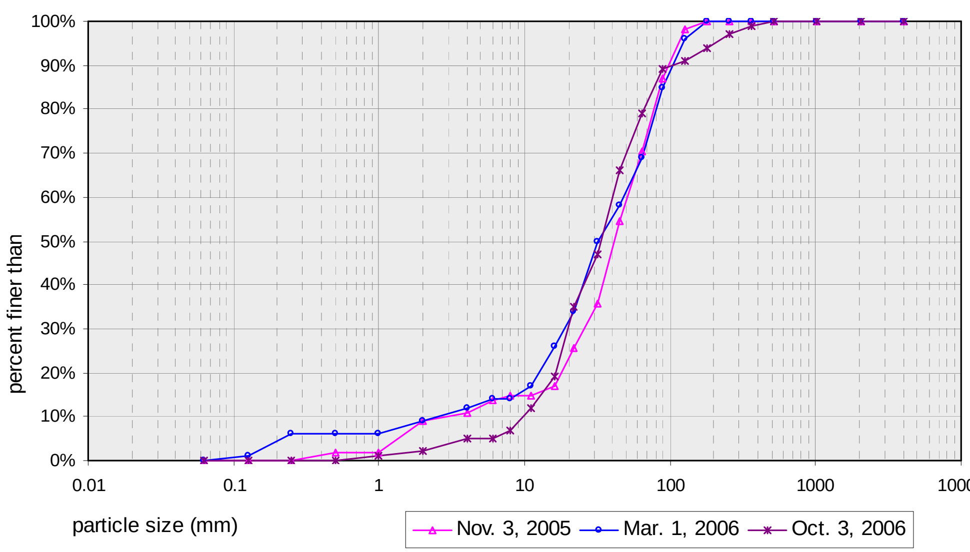
Site A - Upstream of Lee Highway Bridge




Site B - Below Lee Highway at Harley Dealer




Site C - Upstream of Old Lee Highway

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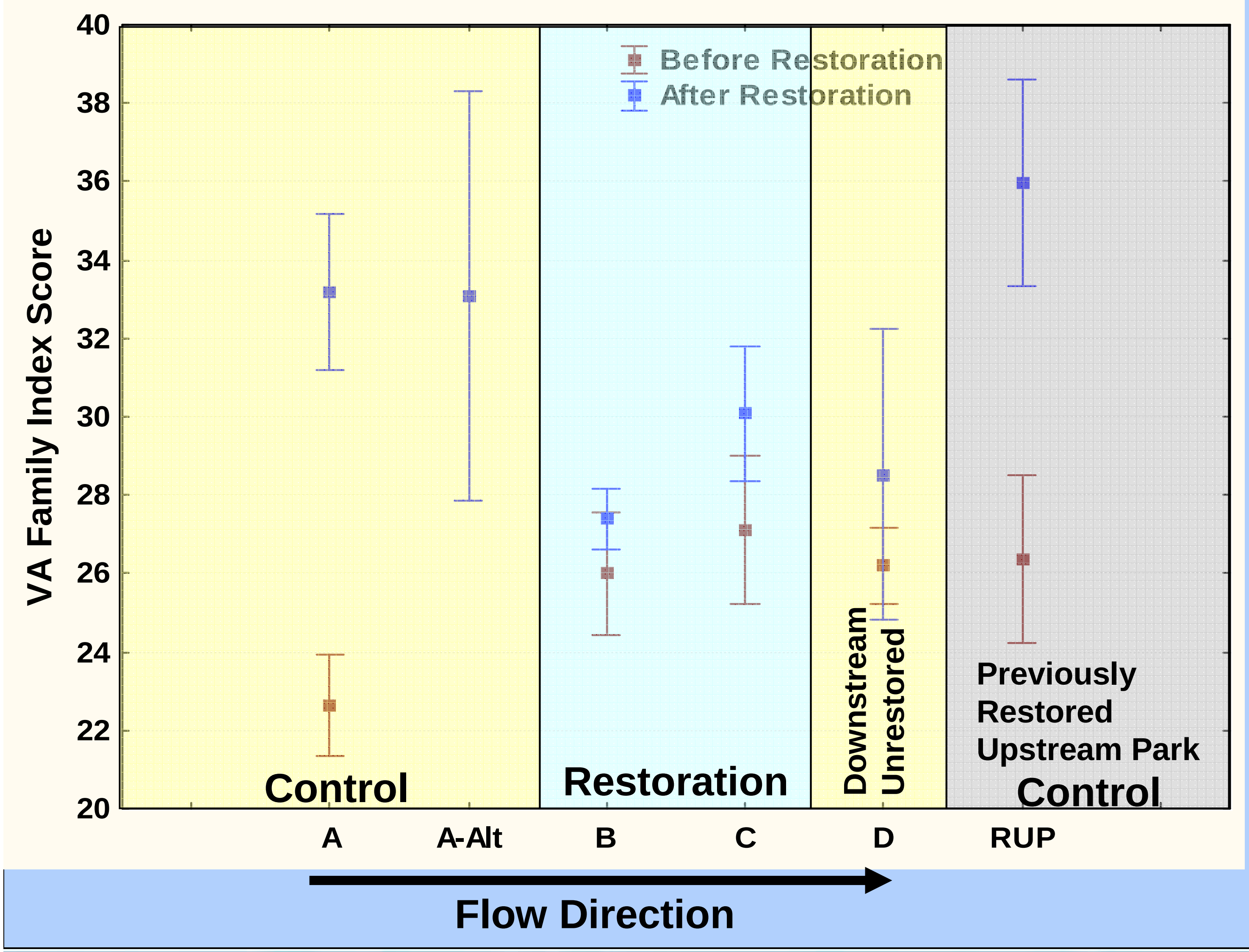
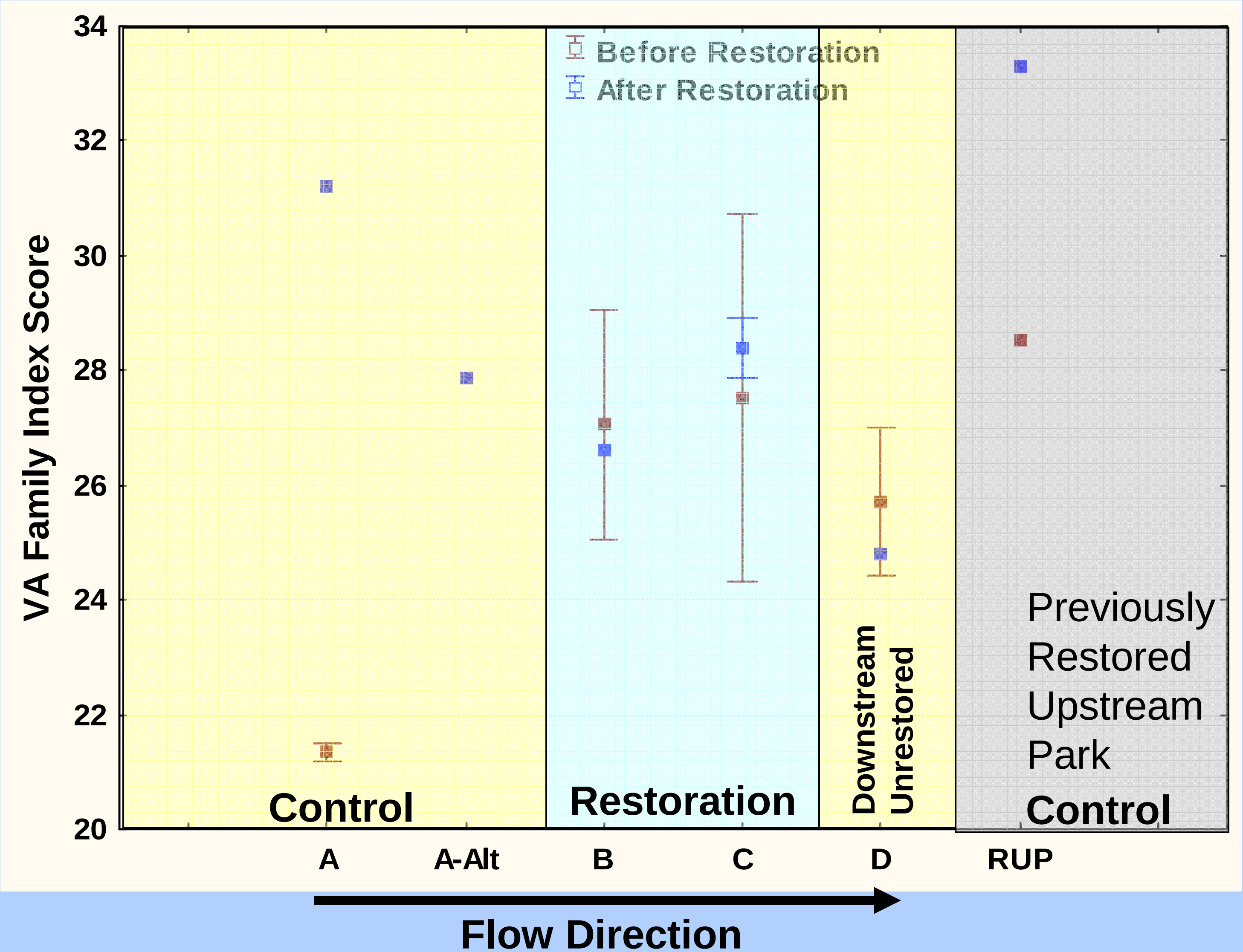
# *Macroinvertebrate Indices-Overall*

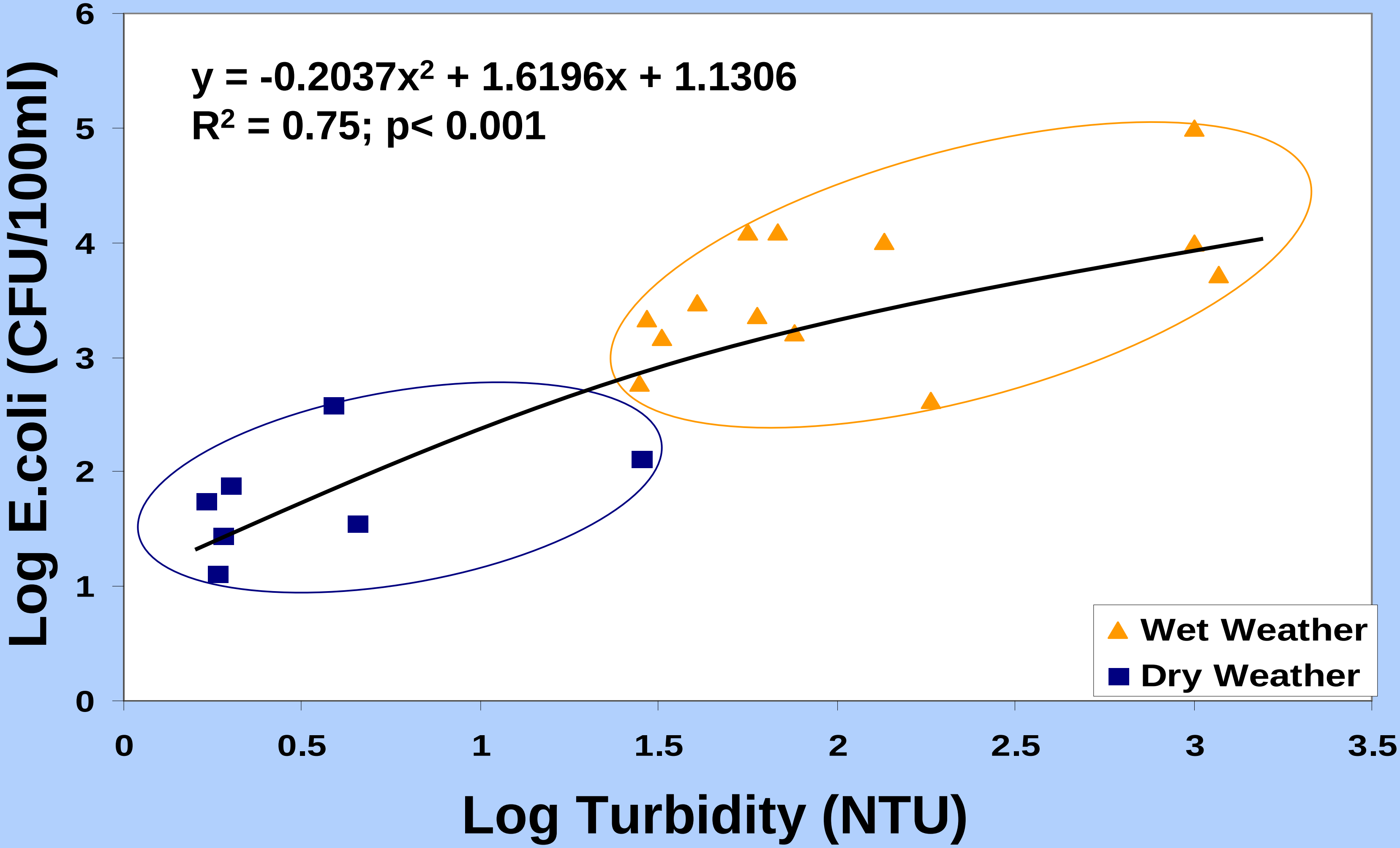



Source: Using Probabilistic Monitoring Data to Validate the Non-Coastal Virginia Stream Condition Index. 2006. VDEQ Technical Bulletin WQA/2006-001

# *Macroinvertebrate Indices-Fall*



# *Dry and Wet Weather Contribution?*



# *What is the source of fecal contamination?*

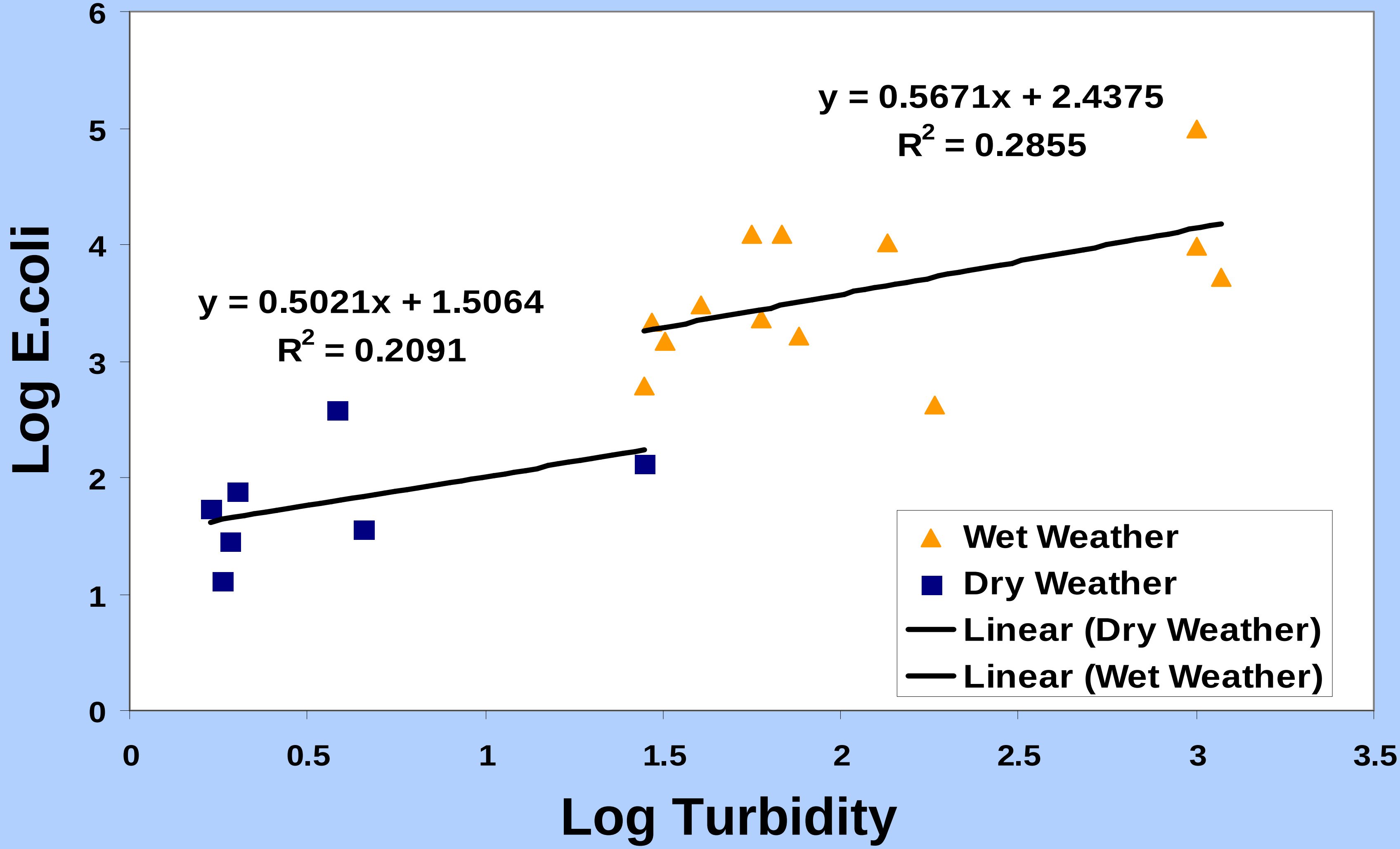
?

?

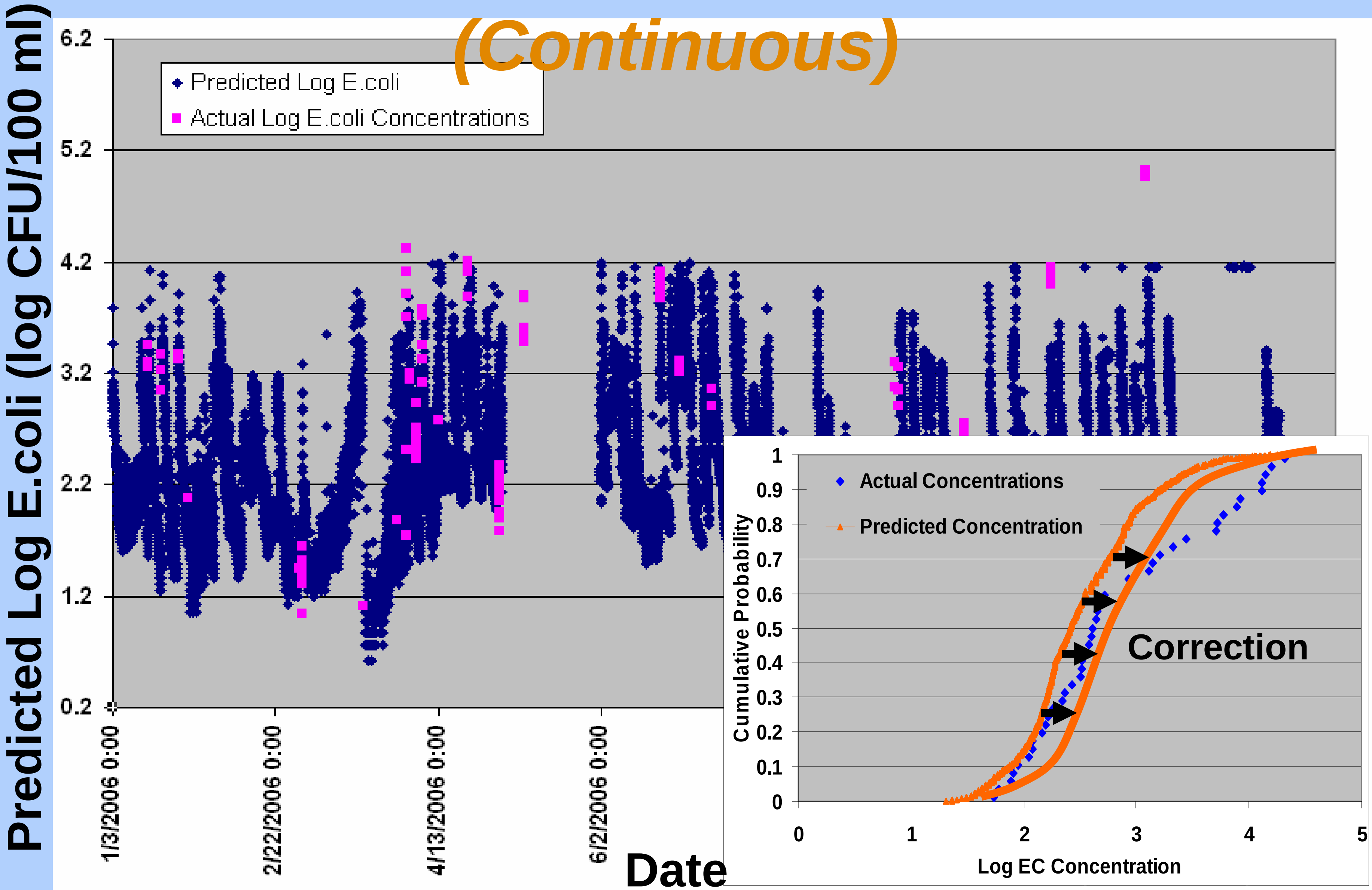
?

**The source affects the predictive relationship!**

# *Dry and Wet Weather Contribution?*



# Predicted E. coli Based on Turbidity (Continuous)



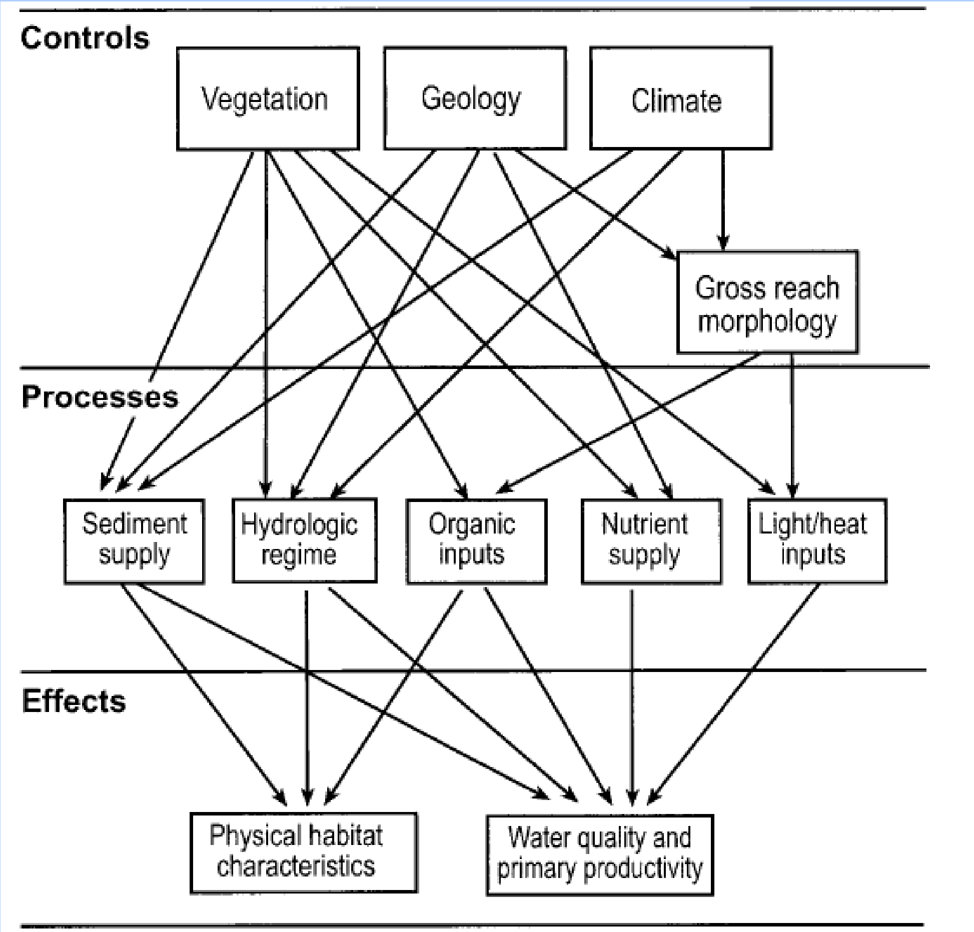
# Future Directions Phase I & II

- Continuous monitoring of WQ and flow
- Collect WQ wet and dry weather discrete samples
- Quarterly biological sampling
  - Benthic macroinvertebrate sampling
  - Vegetation
  - RBP habitat assessment
- Annual stream morphology sampling
  - Cross-sectional sampling
  - Longitudinal surveying
- Quarterly stream pebble counts
- Sampling of other implemented watershed improvements (based on priority list)
- Link with economic benefits?

# *Is the Goal of Restoring Hydrologic Conditions Achievable?*

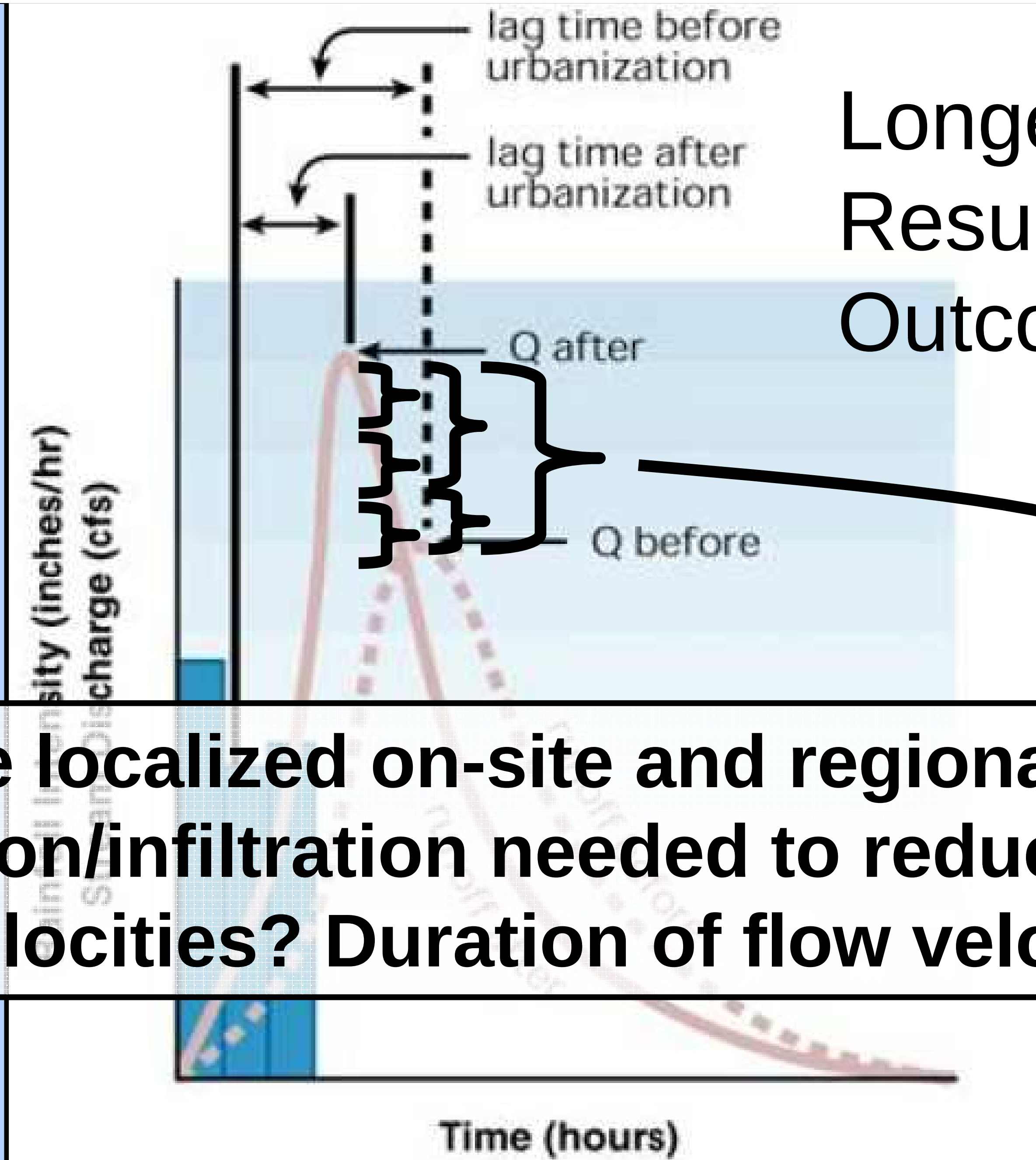
**Stream restoration is one tool to protect banks and infrastructure in urban watersheds**

Incremental or partial restoration of key controls and processes is necessary (i.e., hydrologic conditions).




Roni et al., 2002

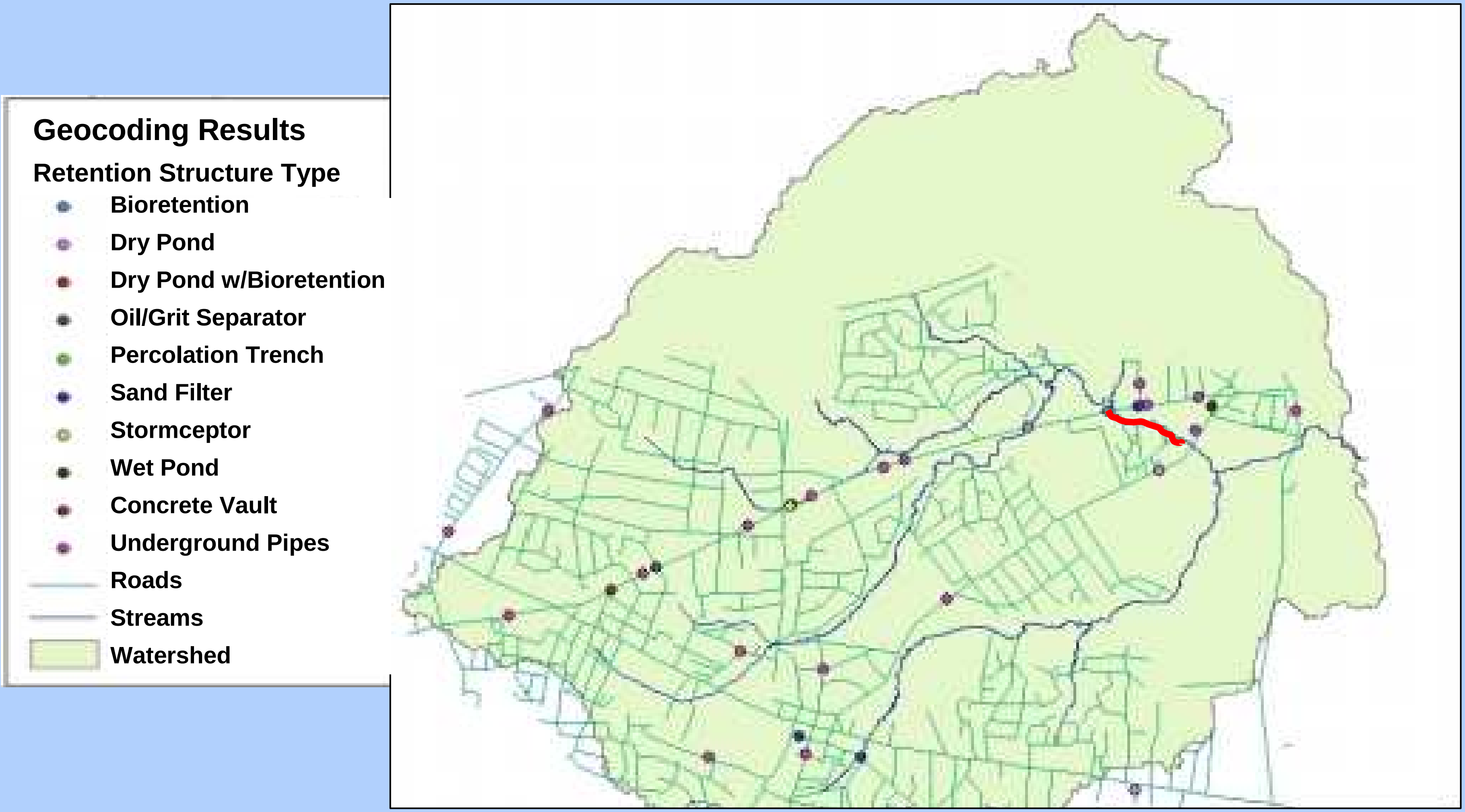
**Other management practices are also needed!**




Longer Term Results and Outcomes?

**Is more localized on-site and regional detention/infiltration needed to reduce peak flow velocities? Duration of flow velocity?**

# Existing BMP Type and Location



# Potential Retrofits for Upland and Watershed Management

| Type of Site | Site Name | Proposed Practice | Drainage Area (ac) | Impervious Area (ac) |
|---|---|---|---|---|
| Detention pond and other LID controls for impervious area | Fairfax High School | Pond/ wetland and Other | 29.36 | 12.66 |
| | Outfall behind Mazda dealership | Pond/ wetland | 62.58 | 21.87 |
| Dry Pond Conversion | Outback Steakhouse and Kentucky Fried Chicken | Dry pond conversion | 2.46 | 2.02 |
| | Bank of America | Bioretention | 0.98 | 0.72 |
| Bioretention/ Swales | Police Station | Bioretention | 0.95 | 0.29 |
| | Bowl America - Back | Dry swale | 2.31 | 2.24 |
| | Van Dyck Park - Gravel Parking Lot | Bioretention | 1.61 | 0.62 |
| | Draper Park | Rain gardens | 3.39 | 0.84 |

**Team with City and others!!!**

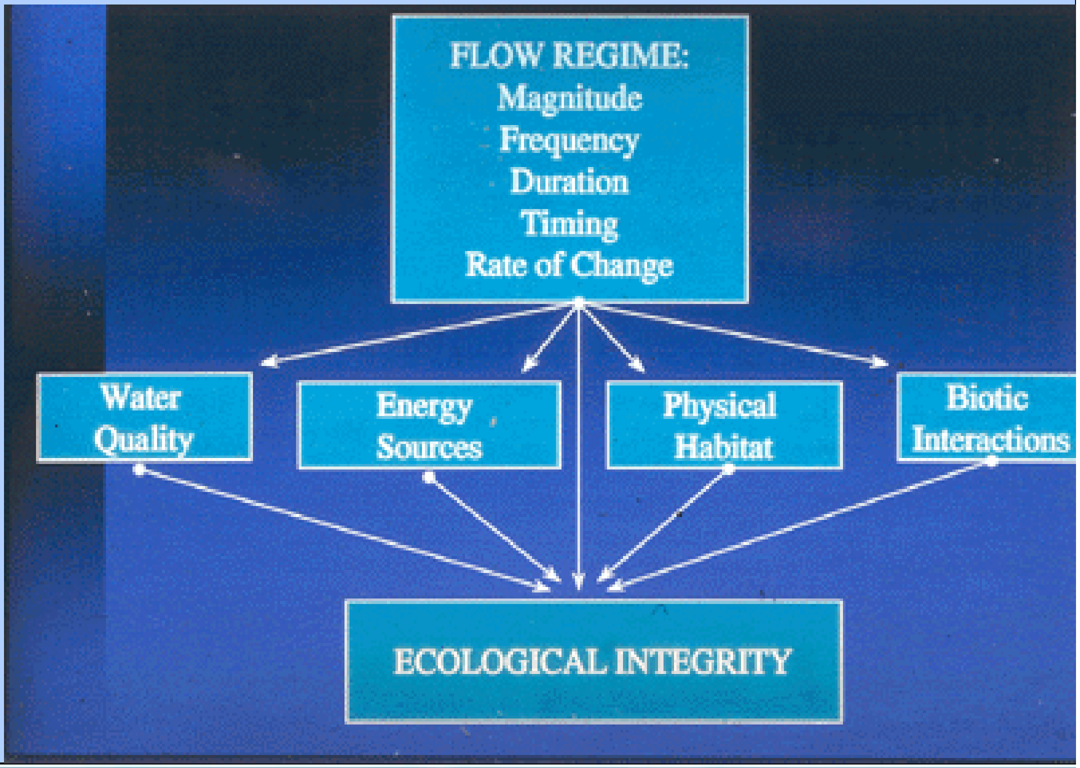
# Conclusion

**Provide case study information to MS4's**

- Reasonable WQ and habitat improvement tools and expectations for stream restoration (and other longer term watershed management)

- Improved hydrologic conditions and lower sediment loads through watershed management

***Will improve in-stream ENERGY and WATER QUALITY with ECOLOGICAL INTEGRITY following***



# Acknowledgements


- US EPA-ORD NRMRL/WSWRD/UWMB
- US EPA EPA Region III
- US EPA EPA Region III – Laboratory, Wheeling, WV
- US EPA Environmental Technical Council's Urban Runoff Action Team - Pilot Project
- City of Fairfax, Virginia
- Center for Watershed Protection
- George Mason University
- Virginia Department of Environmental Quality
- Northern Virginia Regional Commission
- PARS Environmental
- Friends of Accotink Creek (nonprofit)

**Partners to add**

- Fairfax County, Virginia
- Others?



# *Questions?*

**www.epa.gov/ORD/NRMRL/news/news072006.html**